A New Approach to

Environmental Research

and Technology Development

at the U.S. Department of Energy

Action Plan

January 25, 1994

Prepared by the U.S. Department of Energy

Contents

Contents (Cont.)

Acronyms

BES	Basic Energy Sciences (Office of Energy Research)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
D&D	decontamination and decommissioning
DNAPL	dense non-aqueous phase liquids
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DOIT	Development of Onsite Innovative Technologies
DP	Office of Defense Programs
EE	Office of Energy Efficiency and Renewable Energy
EH	Office of Environment, Safety and Health
EM	Office of Environmental Restoration and Waste Management
EM-20	Office of Oversight and Self-Assessment
EM-30	Office of Waste Management
EM-40	Office of Environmental Restoration
EM-50	Office of Technology Development
EM-60	Office of Facility Transition and Management
EPA	U.S. Environmental Protection Agency
ER	Office of Energy Research
EMAC	Environmental Management Advisory Committee
FE	Office of Fossil Energy
FFCAct	Federal Facility Compliance Act of FY 1992
LDR	Land Disposal Restriction
LNAPL	light non-aqueous phase liquid
M&O	Management and Operations
MLLW	mixed low-level waste
MTRU	mixed transuranic waste
MWIR	Mixed Waste Inventory Report
NOA	National Governors' Association
NIST	National Institute of Standards and Technology
OHER	Office of Health and Environmental Research
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
RW	Office of Civilian Radioactive Waste Management
STGWG	State and Tribal Government Working Group
VOC	volatile organic compound
WGA	Western Governors' Association
WIPP	Waste Isolation Pilot Plant

1.0 Managing for Success

The U.S. Department of Energy (DOE) is committed to improving the effectiveness of all its programs and organizations. In support of this commitment, the Office of Environmental Restoration and Waste Management (EM) in cooperation with other DOE research organizations will use the best science and technology available to solve the most challenging set of environmental problems in the world. By applying the principles of Total Quality Management and strategic planning, DOE will achieve measurable progress in developing and applying technology that can support the EM mission in the most cost-effective and timely fashion. This approach will build upon existing programs and will seek continual improvement of all EM operations and processes.

This Action Plan describes a new approach to managing DOE's environmental research and technology development activities. The EM and its technology development activities have entered a new phase. Integral to this is an up-front awareness of program needs obtained from customers, users, regulators, and stakeholders, and a matching of these needs to the suppliers of technological solutions. This solutions-oriented approach will provide these linkages. The goal of this new approach is to conduct a research and technology development program that is focused on overcoming major obstacles to progress in cleaning up the DOE sites and that involves the best talent in DOE and the national science communities.

The key features of the new approach are:

- Teaming with the customers in EM to identify, develop, and implement needed technology.
- Focusing technology development activities on major environmental management problems.
- Ensuring coordinated management of all scientific and development activities in support of EM.
- Focusing all available resources in National Laboratories more effectively.
- Involving industry in developing and implementing solutions including both technology transfer into the Department and technology transfer from DOE to the private sector.
- Strengthening basic research by involving academia and other research organizations to stimulate technological breakthroughs.
- Enhancing mechanisms for regulator and stakeholder involvement.
- Enhancing mechanisms for implementing technology development results.

A comprehensive, balanced set of plans is being developed to integrate and guide all EM environmental research and technology development toward common goals using consistent strategies.

People from throughout affected DOE organizations are actively working together to form teams that address the major problems facing EM.

This Action Plan is presented in three sections. This section outlines the following major steps for achieving the new approach: evaluating the current situation in environmental research and technology development, focusing all efforts on major problem areas, implementing a new approach to address these specific problems, forming essential partnerships and linkages, applying metrics for success, and taking action. The second and third sections provide examples of the application of the new approach to two specific problem areas: 1) contaminant plume and remediation and 2) mixed waste characterization, treatment, and disposal. While subject to revision, these examples provide specific information on coordination of technology development programs and proposed focused technology thrusts within each of the two problem areas. In addition, these two sections demonstrate important aspects of the integrated team structure for these specific problems and outline necessary actions.

1.1 Evaluating the Current Situation

The EM was established in November 1989 and was tasked with cleaning up the legacy of environmental pollution at DOE weapons complex facilities, preventing further environmental contamination, and instituting responsible environmental management. It has become apparent that the magnitude and complexity of many aspects of this mission are such that it cannot be achieved using existing technology without incurring unreasonable cost, risk, or schedule impact. Consequently, an aggressive program of innovative technology development must be pursued if program goals are to be achieved.

Within EM, the Office of Technology Development (EM-50) is responsible for managing the national program of environmental applied research and technology development. In addition to the activities of EM-50, other technology development activities are being accomplished by the Offices of Waste Management (EM-30) and Environmental Restoration (EM-40). Also, the Office of Energy Research (ER) is conducting basic research that might be of long-term benefit to EM problems. DOE's Offices of Defense Programs (DP); Environment, Safety and Health (EH); Energy Efficiency and Renewable Energy (EE); Civilian Radioactive Waste Management (RW); and Fossil Energy (FE) are potential contributors to environmental research and technology development.

Within EM-50, there are established programs that address specific technical areas, crosscutting programs that provide coordinated support to these areas, and integrated demonstrations of multiple technologies at various sites across the DOE weapons complex. Organizations and personnel have been assigned to carry out these programs. The major challenge facing EM is to focus existing efforts on the major problem areas while more effectively coordinating technology development with customer needs.

To focus Department-wide environmental research and technology development activities on DOE's most pressing environmental restoration and waste management problems, the Assistant Secretary for EM established a Working Group to develop and implement this new approach. This Action Plan, a product of the Working Group's efforts starting in August 1993, establishes the framework and strategies for coordinating efforts among DOE Headquarters organizations and Operations Offices, Management and Operations (M&O) Contractors, the National Laboratories, other government agencies, the scientific community, industry, and the affected public.

1.2 Focusing on Major Problem Areas

Five major remediation and waste management problem areas have been identified to date within the DOE weapons complex. These problems have been targeted for action on the basis of risk, prevalence, or need for technology development to meet environmental requirements and regulations. In the future, additional areas may be added (or currently identified areas further partitioned) to ensure that research and technology development programs remain focused on EM's most pressing remediation and waste management needs. These major problem areas are termed focus areas.

Contaminant Plume Containment and Remediation. Uncontained hazardous and radioactive contaminants in soil and ground water exist throughout the DOE weapons complex. There is insufficient information at most sites on the contaminants' distribution and concentration. The migration of some contaminants threatens water resources and, in some cases, has already had an adverse impact on the offsite environment. Many of the current characterization, containment, and treatment technologies are ineffective or too costly. Improvements are needed in characterization and data interpretation methods, containment system, and in situ treatment.

Mixed Waste Characterization, Treatment, and Disposal. DOE faces major technical challenges in the management of low-level radioactively contaminated mixed waste. Several conflicting regulations and lack of definitive mixed waste treatment standards hamper mixed waste activities. Disposal capacity for mixed waste is also expensive and severely limited. DOE now spends millions of dollars annually to store mixed waste because of the lack of accepted treatment technology and disposal capacity. Currently available waste management practices require extensive, and hence expensive, waste characterization before disposal. Therefore, DOE must pursue technology that leads to better and less expensive characterization, retrieval, handling, treatment, and disposal of mixed waste.

High-Level Waste Tank Remediation. Across the complex, hundreds of large storage tanks containing hundreds of thousands of cubic meters of high-level mixed waste present a problem that has received much attention from both the public and DOE. Primary areas of concern are deteriorating tank structures and consequent leakage of their contents. Research and technology development activities must focus on the development of safe, reliable, cost-effective methods for characterization, retrieval, treatment, and final disposal of the wastes.

Landfill Stabilization. Numerous DOE landfills pose significant remediation challenges. Some existing landfills have contaminants that are migrating, thus requiring interim containment prior to final remediation. Materials buried in "retrievable" storage pose another problem -- the development of retrieval systems that reduce worker exposure and reduce the quantity of secondary waste.

Development of in situ methods for both containment and treatment is also a high-priority need.

Facility Transitioning, Decommissioning, and Final Disposition. The aging of DOE's weapons complex facilities, along with the reduction in nuclear weapons production, has resulted in a need to transition, decommission, deactivate, and dispose of numerous facilities contaminated with radionuclides and hazardous materials. While the building and scrap materials at the sites are a potential resource with a significant economic value, current regulations lack clear release standards, and thus indirectly discourage the recovery, recycling, and/or reuse of these resources. Development of enhancer technologies for the decontamination of these materials and effective communication of the low relative risks involved are promising avenues toward the recovery, recycle, and/or reuse of these resources. In addition, material removal, handling, and processing technologies must be improved to enhance worker safety and reduce cost.

Crosscutting activities, such as characterization or robotics, and potential overlap in the boundaries of the focus areas will be dealt with by the Management Teams in conjunction with the Steering Committee.

1.3 Implementing the New Approach

A new approach has been formulated to focus DOE-wide environmental research and technology development activities on these pressing environmental and waste management problems. The centerpiece of the new approach is an integrated, multi-organizational team focusing on the major problem areas. This approach will facilitate the involvement of the best talent within DOE and the national science communities, more closely integrate basic research with the EM program, enhance communications between customer (i.e., problem holder) and technology developer, and engage stakeholders and regulators in research and technology development planning and implementation activities. Continuous quality improvements in EM operations will be a major outcome.

Identifying the customer is important within the context of this program. To facilitate the understanding of this new approach, two customers have been identified. One is "EM Headquarters," which is responsible for cleaning up and managing wastes at DOE weapons complex sites across the United States. The other is responsible DOE field representatives. Participation of the customers throughout the problem definition, decision, management, and implementation process is critical to the success of this new approach.

1.3.1 EM Technology Management Process

A technology management process, depicted in Figure 1.1, was developed to provide the framework for identifying technology needs and developing effective, acceptable technology solutions. Integral to the design of this technology management process is teaming: the integration of customer needs, suppliers of technology-based solutions, and stakeholders.

The technology management process provides for rigorous, systematic, and effective management of environmental research and technology development activities, specifically: 1) a clear and concise description of specific environmental management problems and specific plans that focus technology development efforts to support customer needs; 2) consideration of current technologies and ongoing technology development activities to solve problems; 3) performance evaluation of existing or newly developed technologies to determine if an effective, acceptable solution exists; and 4) successful transfer of developed technologies to the customer for implementation and to the private sector for commercialization.

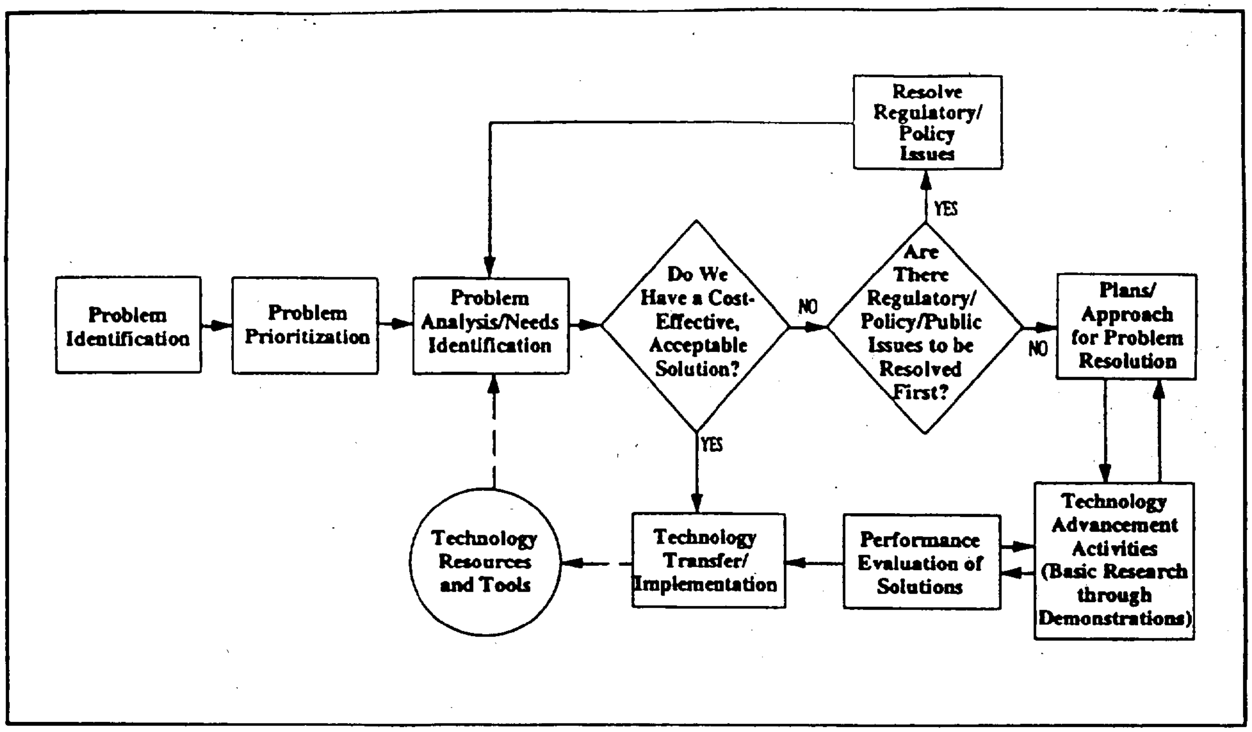

Figure 1.1 Technology Management Process

1.3.2 Integrated Team Structure

The structure for managing and implementing environmental research and technology development is shown in Figure 1.2. The present administrative structure is not superseded in this new approach.

Primary elements of the team structure include the following:

- *Steering Committee* -- sets overall direction, establishes policy and priorities, oversees the functions of all Management and Implementation Teams, monitors progress, allocates financial resources, and resolves conflicts among focus areas.

- *DOE National Environmental Science and Technology Council* -- provides advice on high-level priority and resource issues and overall programmatic matters to the Assistant Secretary, Environmental Management, and the Steering Committee, as requested. Serves as a bridge to National and International scientific communities.

- *Management Team* -- sets policy and direction within a focus area, plans and coordinates work across the focus area, and monitors the implementation of technology development efforts.

- *Implementation Team* -- led by a Lead Organization, proposes the integrated technical approach, provides the day-to-day technical management, and carries out research and development activities associated with the program.

- *Focus Area Review Groups* -- serve on an ad hoc basis as expert resources to the Management and Implementation Teams for conducting peer reviews and advising on technical issues.

- *Site Technology Coordination Groups* -- consolidate technology needs at the site, enhance communications within programs and with local regulators on technology development activities, and provide day-to-day technology transfer functions both within and across sites.

The following paragraphs discuss the roles and responsibilities of each element within the integrated team structure and describe the membership of these elements. In addition, the competitive selection process for the Lead Organization is discussed.

Steering Committee

The Steering Committee provides top-level program oversight and ensures that the technology development program continues to be responsive to EM priorities. The committee reviews actions of each Management/Implementation Team, establishes overall priorities and policy, provides programmatic direction, allocates financial resources for the focus area, and addresses procedural and coordination issues that crosscut all focus areas.

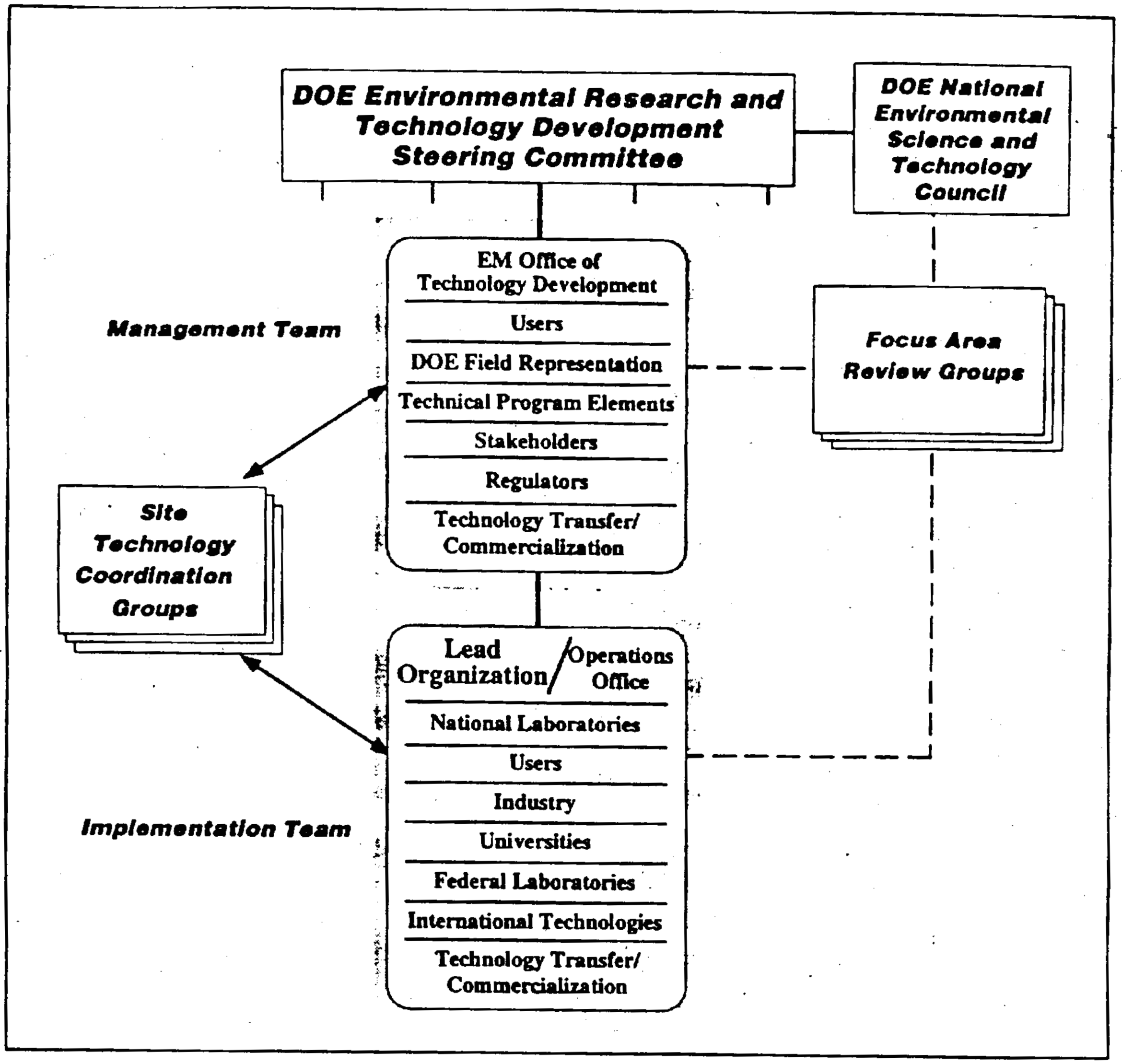

Figure 1.2 Integrated Team Structure

The Steering Committee will include Deputy Assistant Secretary/Associate Deputy Assistant Secretary-level representatives from each EM organizational element. The Secretary of Energy, Under Secretary of Energy. Assistant Secretary for Environmental Management, and the Director, Office of Energy Research, shall be invited to serve as ex-officio members. The Deputy Assistant Secretary for Technology Development will serve as the Working Chair of the Steering Committee. Membership on the Steering Committee will also include senior-level representatives from other program offices making a contribution to a coordinated environmental research and technology development program (e.g., DP, EE, ER, and RW). Senior-level representation from within the Department and other government agencies, such as the U.S. Environmental Protection Agency (EPA), National Institute of Standards and Technology (NIST), and the U.S. Department of Defense (DoD), may act in an advisory capacity.

The Steering Committee is responsible for:

- Ensuring that the technology development program is solution-oriented, addresses EM's most urgent cleanup problems, is fully integrated across EM and with other DOE organizations, and addresses program goals.

- Setting overall strategic direction and providing top-level policy and guidance.

- Establishing new focus areas as required.

- Setting priorities and allocating financial resources among focus areas.

- Approving the type of lead organization.

- Establishing and overseeing the functions of the Management Team, including the delegation of necessary responsibilities and accountability.

- Developing general criteria for selection of the Implementation Team.

- Approving selection of the Implementation Team.

- Incorporating key information and needs brought to the committee by non-DOE members.

- Providing administrative/procedural coordination among focus areas and overseeing development of crosscutting management systems.

- Establishing general, crosscutting peer review guidelines.

- Facilitating coordination and integration among Management and Implementation Teams and DOE organizations.

- Arranging for a secretariat function to support the DOE National Environmental Science and Technology Council.

The Steering Committee will meet periodically to provide policy guidance and direction, review progress, and adjudicate conflicting priorities or positions. The DOE National Environmental Science and Technology Council will be utilized to review the environmental research and technology development program and will report during these meetings.

The Steering Committee will seek the advice of the Council in carrying out its responsibilities. The Council will also provide appropriate reports to the Steering Committee regarding specific science or engineering issues.

DOE National Environmental Science and Technology Council

The DOE National Environmental Science and Technology Council will report to the Assistant Secretary for Environmental Management, as an ex-officio member of the Steering Committee, and will advise the Steering Committee. Scientists and engineers with national and international reputations in their fields of expertise will comprise this Council. It may also include stakeholders and public policy specialists of national stature.

To operate effectively, the DOE National Environmental Science and Technology Council will be provided by the Steering Committee with an executive secretariat. The Council will review and advise on high-level priorities and the use of national talents and resources. This review of priorities will ensure that the basic and directed research elements are integrated into EM programs, as well as ensuring that overall EM research and development objectives are being met. The Council will perform independent technical reviews and evaluations of priorities on an as-needed basis to ensure that EM program goals are met and duplication of effort is avoided.

The DOE National Environmental Science and Technology Council will serve as technical outreach to nationally recognized talents and resources outside the DOE system. As such, the Council will provide an avenue for key contacts to the scientific community to ensure the best possible scientific and engineering approaches are pursued.

Management Team

The Management Team sets policy and direction within each focus area, plans and coordinates work across the focus area, and monitors the implementation of technology development efforts. Each Management Team will consist of representatives from each contributing organizational element. The core team will consist of one representative each from EM-30, EM-40, EM-50, the Office of Facility Transition and Management (EM-60), and an Operations Office representative, as appropriate. The Management Team can also include representatives from DOE technical program elements (e.g., EM-20, FE, EH, EE, ER, DP, and RW), as well as technology users, stakeholders, regulators, and technology transfer and commercialization specialists. The Headquarters Program Managers who have programmatic responsibilities within a particular focus area will participate on the Management Team for that area. The Program Managers' responsibilities and authorities will be maintained.

The Management Team has overall programmatic responsibility and accountability, and directs the Implementation Team and delegates to it the day-to-day technical management responsibility and accountability necessary for implementation of projects within the focus area. The Management Team is responsible for authorizing work that has been approved from the comprehensive program proposed by the Implementation Team. The Management Team is also responsible for ensuring that funds are disbursed to the appropriate performing organizations.

The roles of the Management Team include the following:

- Translating the Steering Committee's top-level policy guidance and direction into focus area-specific strategic plans and strategies for implementation.
- Validating and prioritizing needs within the focus area.
- Issuing program guidance for technology development activities.
- Committing resources.
- Providing metrics to the Lead Organization for evaluating program performance.
- Approving Implementation Plans and changes to plans.
- Developing focus area-specific criteria for selecting the Lead Organization.
- Recommending the type of Lead Organization to the Steering Committee.
- Selecting the Lead Organization subject to the approval of the Steering Committee.
- Ensuring the opportunity for innovative (breakthrough) research relevant to the focus area.
- Coordinating/integrating with other Management Teams (except for major issues such as resource allocation questions).
- Establishing peer review procedures for specific focus area efforts.
- Ensuring a "seamless" set of activities from basic research through commercialization.
- Reviewing the technical program conducted by the Implementation Team.
- Reviewing the program against performance objectives.
- Resolving issues or forwarding unresolved issues to the Steering Committee.
- Soliciting and receiving customer needs from the Site Technology Coordination Groups and appropriate Headquarters elements.

- Selecting and using the Focus Area Review Group to provide peer reviews of ongoing and proposed technical work.

- Soliciting stakeholder input, as discussed in Section 1.4.1.

Implementation Team

The Implementation Team is responsible for day-to-day technical management and is accountable for the technical effort and progress within the focus area. A Lead Organization is responsible for the Implementation Team. To exercise its technical leadership, the Team must be constituted with the best scientific and technical expertise available in the Federal, industrial, and academic communities. Responsibilities of the team include formulation of specific projects to be conducted by the National Laboratories, private sector research organizations, industry, and universities; and the exercise of technical program/project management to ensure the projects' timely progress toward focus area objectives. Selection of the Lead Organization for a focus area will be performed by the Management Team, with approval of the Steering Committee.

The roles of the Implementation Team include the following:

- Develops and proposes a comprehensive technical program plan for the focus area spanning basic research through commercialization.

- Provides system integration, including technical, cost, and schedule components within the focus area.

- Carries out research and development activities.

- Develops a life-cycle approach to solve problems and satisfy customer needs.

- Recommends allocation of resources for implementation activities.

- Manages and is accountable for project, cost, and schedules.

- Tracks performance using metrics provided by the Management Team.

- Compiles information about, and advises on, currently available and developing technologies in the United States and abroad.

- Integrates national technology transfer and commercialization efforts through private sector representation.

- Fosters awareness of program accomplishments (new technology developments).

- Monitors progress and performance of program components.

- Ensures implementation of approved plans.

- Issues calls for proposals for research and technology development activities.

- Recommends changes to the Focus Area Strategic Plan to the Management Team.

Focus Area Review Groups

The Focus Area Review Groups will be established as needed to conduct independent reviews and to provide recommendations to Management and Implementation Teams on priorities and the technical merit of the proposed and ongoing programs and technologies. This would include recommendations regarding the elimination of work to avoid duplication of effort.

A key function of these Groups will be to serve as a resource in evaluating programs to ensure that a "seamless" set of activities from basic research through commercialization is encouraged and promoted. This includes evaluation and advice on fostering innovative research, adapting technologies not originally developed for EM use, improving existing technologies, and providing recommendations on procedures and mechanisms for the transfer and commercialization of new technologies.

Membership of the Focus Area Review Groups will be chosen on an ad hoc basis. The Focus Area Review Groups will include scientists, engineers, and interested stakeholders. A member of the DOE National Environmental Science and Technology Council may serve as a member on or may chair a Focus Area Review Group. The Focus Area Review Groups will work with both the Management and Implementation Teams to ensure success of the program. This may include the tailoring of general peer review guidelines for selected focus area efforts. The Focus Area Review Groups will make advisory reports to both the Management and Implementation Teams and, as appropriate, to the DOE National Environmental Science and Technology Council.

Site Technology Coordination Group

A Site Technology Coordination Group will be established at each DOE site, serving as the site representatives of the customers, to work with the Management and Implementation Teams to ensure that site needs are identified and addressed and that developed technical solutions are implemented. The membership of the Site technology Coordination Group should include representation from EM-30, EM-40, EM-50, and EM-60 activities. Subgroups may be established as appropriate to address specific issues.

Site Technology Coordination Groups will be co-led by an Operations Office Technical Program Officer and a user representative as determined by the Operations Office. The Operations Offices shall have the flexibility to organize each Site Technology Coordination Group in the manner it deems most beneficial for solving the site's problems. Membership of each Group should include Operations Office personnel as well as operating contractor and laboratory personnel from the site. Local regulators will be kept informed of technology development by the Site Technology Coordination Group. Stakeholders and public interest groups should be actively involved with the Site Technology Coordination Group. Involvement at the local level will provide for early stakeholder input as technology needs are identified and technologies are considered for implementation at the site.

Site Technology Coordination Groups provide prioritized site needs and required implementation dates. Members on the Site Technology Coordination Groups will review and comment, through their representative on a Management Team, on the strategic plan, direction, and priorities established by the Management Team to determine if the site's needs are properly addressed. Site Technology Coordination Groups will work with more than one Management and Implementation Team because each site has problems that encompass more than one focus area.

Site Technology Coordination Groups will interface regularly with the Implementation Team to monitor technologies being developed that are applicable to the site. Information, such as required technology performance criteria, and specific waste types and quantities, will be provided to the Implementation Team. Site Technology Coordination Groups will work with the Implementation Team to facilitate demonstration of a technology at a site. After a technology is successfully demonstrated, Groups are responsible for ensuring its implementation by the user program.

Groups should be used to optimize data gathering that supports technology development efforts during normal field operations without adversely impacting regulatory milestones. The Groups would provide access to existing characterization data to support comparisons with new approaches, provide opportunities to collect additional samples during field work that support development efforts, and ensure the availability of waste generated during operations that can support technical development efforts.

Selection Process for Lead Organization

Lead Organizations will be selected for each focus area following a process and general guidelines developed by the Steering Committee. This process will address, among other things, protection of proprietary information and intellectual property. The Management Team, with the approval of the Steering Committee, will determine the type of Lead Organization, which may include DOE Operations Offices, National Laboratories, M&O contractors, universities, non-profit or not-for-profit organizations, industry, or other interested organizations. The responses developed during this process would have to be sufficiently detailed to demonstrate capabilities and understanding. For example, broad teaming relationships and technical thrusts would be proposed but not detailed technical tasks.

Each interested party or consortium provides its proposal to the Management Team. The Management Team will evaluate the proposals and recommend a Lead Organization to the Steering Committee, which approves the recommendations or directs the Management Team to reconsider the selection. After selection, an Implementation Plan will be developed which is responsive to the Strategic Plan issued by the Management Team.

A Lead Organization will be selected for each focus area on the basis of proposals addressing such factors as the following:

- Quality and extent of scientific and organizational commitment and capabilities.

- Non-technical capabilities and track record in strategic and implementation plans, day-to-day management, technical management, business and marketing, laws and regulations (technical, patent, procurement, etc.), commercialization, technology transfer, procurement, cost/schedule/scope/milestone management, external peer review, and integration across systems and other sectors.

- Teaming and linkages with laboratories, M&O contractors, non-profit organizations, academia, and industry (a requirement) proposed for the integrating function; ability to work in teams.

- Techniques proposed for integration across systems, focus area, and other sectors.

- Insight into the user needs and the issues involved in solving the problems, and the technical composition of the research and technology development activities.

- Proposed speed of technology implementation and commercialization.

- Commitment of the Operations Office(s) to manage involved organizations and support the interfaces required.

- Situation analysis and any recommendations for change.

- Extent of funding leveraged with the private sector and research organizations in the lead organization and in the envisioned technical program.

- Recommendations for selection of and appropriate distribution of funds among technical performers.

- Percentage of funds proposed for product development versus management.

- Techniques proposed for tracking, analyzing, and reporting scope, schedule, and cost performance of all implementation team activities.

- Techniques proposed to ensure continuing and full awareness of the pertinent site needs.

- Quality of the approach.

1.3.3 Project Flow Process

Roles and responsibilities within the management structure may also be described in terms of the process flow associated with a typical project. Figure 1.3 follows a sample need and corresponding solution development through several steps in an attempt to provide perspective. Some details may change as the Management Team resolves operational issues.

1.4 Essential Partnerships and Linkages

Essential to the success of the new approach for managing environmental research and technology development is the involvement and/or development of partnerships between interested and affected individuals and groups.

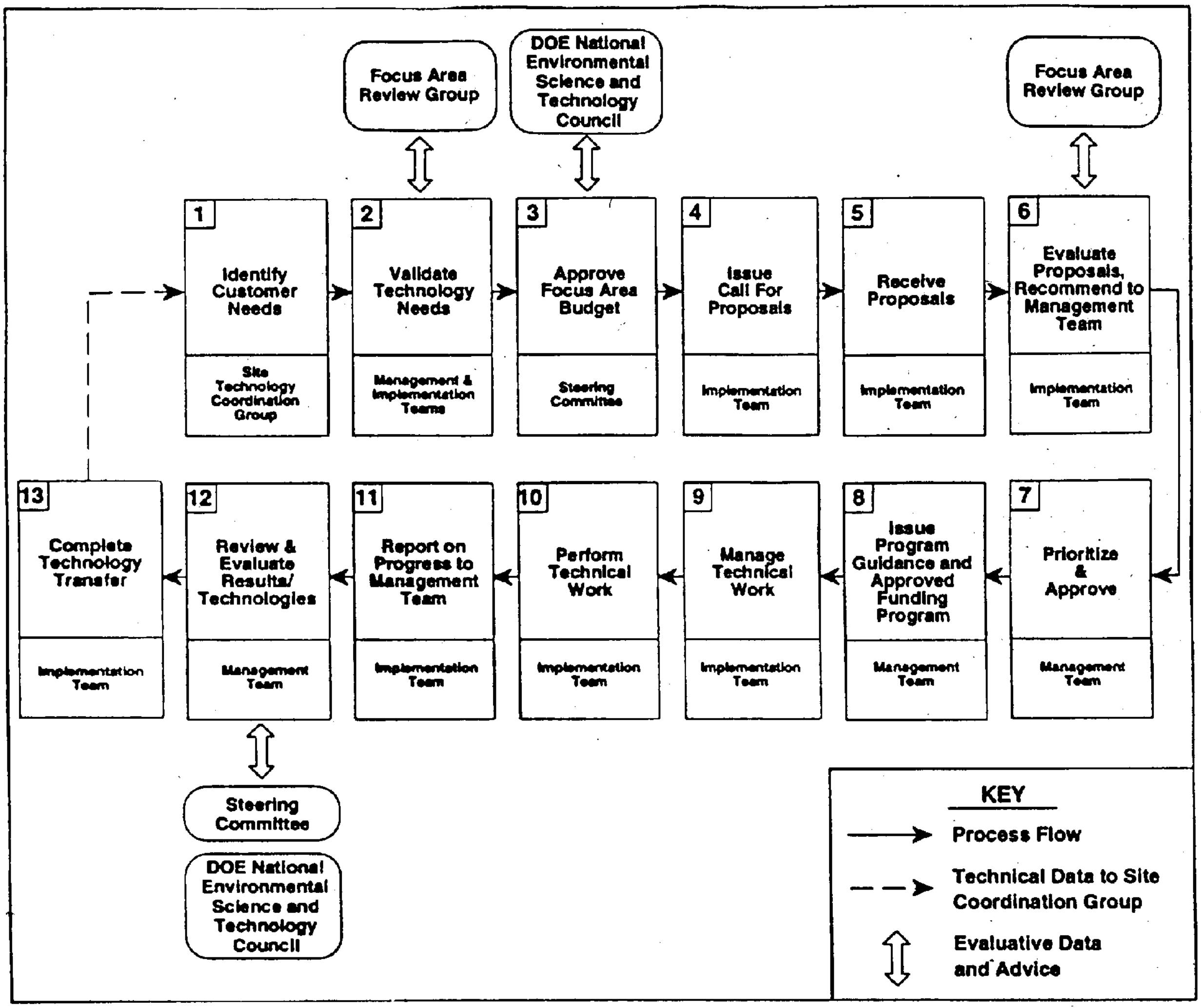

Figure 1.3 Sample Project Flow Process

1.4.1 Stakeholder Involvement

An important aspect of the EM program is to develop stronger partnerships between DOE and its stakeholders. Groups such as the Environmental Management Advisory Committee (EMAC), the National Governors' Association (NGA), the State and Tribal Government Working Group (STGWG), and newly created site-specific advisory boards provide valuable assistance to the Department. In addition, the regional Western Governors' Association (WGA) may provide input to focus area activities.

While stakeholders have participated in EM planning through STGWG, EMAC, and other groups and committees, they perceive that their role in many instances has been limited to review and comment on a virtually completed draft "product" rather than contributing to the formulation of that product. The new approach for accomplishing environmental research and technology development at DOE is designed to reshape EM's partnerships with stakeholders -- to ensure that their concerns are addressed and that DOE reaps maximum benefits from their participation. Stakeholders will be more actively involved in planning, program formulation, and implementation of environmental research and technology development at the local level through Site-Specific Advisory Boards.

At the national level, stakeholder participation has been largely limited to broad EM policy documents (e.g., EM Five-Year Plan, the programmatic environmental impact statement, etc.). Stakeholder participation will now be solicited in conjunction with the work of the Management Team for each focus area. Stakeholder input will be solicited as EM develops strategic plans and sets overall direction for its environmental technology programs. In addition, stakeholders will be encouraged to participate in periodic national reviews to measure program progress. Stakeholder representation on the DOE National Environmental Science and Technology Council and/or the Focus Area Review Groups is also being considered.

1.4.2 Integration Across EM

The most important aspect of this new approach is the coordination of all EM activities and resources directed toward developing and implementing technologies to solve EM's environmental problems. This effort requires the integrated management of all technology development resources available within EM. Duplication of these resources is neither prudent nor cost-effective and it is expected that the integration effort will expose and eliminate duplicative efforts where they exist.

Teaming of the developer with the end user from the start of the process through full-scale implementation is critical to a successful research and technology development program. Teaming should take place through a matrix approach to ensure that technical knowledge is integrated into daily operations and that field experience is integrated into development efforts.

Significant improvements in effective integration are expected by implementing this new approach. Areas to be fully explored by the Management Team and Steering Committee include the following:

- Removal of barriers that prevent the free flow of information within EM. This would include change of the culture to reward sharing of all relevant information; consolidation of internal meetings and external conferences/symposia to reduce duplication; use of the technical expertise available on each of the Implementation Teams to maintain a technology baseline or catalog for each of the focus areas; and integration of needs identification and development efforts.

- Use of technical experts for development of technical alternatives in regulatory-driven documents, such as Feasibility Studies (Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]), Corrective Measure Study (Resource Conservation and Recovery Act [RCRA]), and Site Treatment Plans (Federal Facility Compliance Act of 1992 [FFCAct]).

- Use of experienced personnel for field tests and demonstrations. This might involve the use of people with expertise in cost and schedule development and application, and in regulatory interfaces. People with operational experience would manage field demonstrations.

- Use of existing infrastructures and technology development and demonstration platforms by all parties is inherent in this new approach. Avenues for injecting new technologies into regulatory-driven tests and studies should be fully exploited. These existing infrastructures and platforms include treatability studies (CERCLA and RCRA); EM-50 Integrated Demonstrations and Programs; and demonstration platforms used by the EM-30, including requirements under the FFCAct.

1.4.3 Integration Across DOE

A primary focus of the new approach would be on building, strengthening, and maintaining linkages among EM and other DOE elements. The EM, in conjunction with DP, EE, ER, and RW, will identify areas that constitute major gaps for environmental technology development and seek coordinated efforts in research and technology development to address pressing technology needs -- both short-term and long-term. Where existing technology does not provide near-term solutions, ER and EM can work together in designing and implementing directed research programs. Through this approach, the best science in the nation can be focused on addressing the most significant EM problems. The ER can be a provider of basic research and directed research results; energy-efficient and renewable technologies developed by EE may be modified to meet an EM technology need; and DP can be a provider of radioactive weapons material handling and processing technology. These involvements will help bridge the gap between basic research and solutions to real-world problems.

1.4.4 External Involvement

Many of the external interactions will be coordinated by the DOE National Environmental Science and Technology Council and the individual Focus Area Review Groups. These interactions will include reaching out to the national and international scientific and engineering communities for support of EM goals. Obtaining the endorsement of this community could require comprehensive external oversight and peer review of all research and technology development program elements.

The EM will have to develop strong working relationships with other Federal agencies that have similar problems (e.g., major Federal agency landowners such as the DoD, and the U.S. Department of the Interior [DOI]). These agencies have common environmental restoration concerns and should develop a coordinated inter-agency environmental research and technology development program that produces cost-effective technological solutions. In addition, DOE must develop positive, proactive relationships with EPA and other regulators to foster the acceptance of innovative technologies.

Involvement with the private sector is also important. Not only do many industries have environmental problems similar to DOE, but potential solutions to DOE's environmental problems may also be found in existing technology -- perhaps involving some modification for EM use. Thus, efforts will be undertaken to identify and implement technological solutions now available in the private sector.

New contracting, procurement, and licensing mechanisms must be developed and existing ones must be improved to foster partnering with the private sector and to speed up commercialization of proven technologies. Mechanisms must also be augmented to better integrate the scientific and engineering expertise in the private sector, academia, and non-profit research institutes into the EM technology development program. Partnerships with the private sector will lead to the commercialization of new technologies. Not only will the transfer of technologies to DOE lead to more effective remediation of DOE's environmental problems, but the availability of these technologies can serve as a driving force to improve industrial competitiveness in the global marketplace.

1.5 Applying Metrics for Success

This new approach will employ metrics needed to track the success of the environmental research and technology development program in meeting its objectives. Metrics will be used to ensure that accurate progress can be measured and continually directed to produce the desired results. The program will involve internal and external review to determine success-levels based on these metrics. Metrics can include the following:

- Implementing/commercializing technology.
- Meeting cost and schedule milestones with quality deliverables.
- Increasing industrial and academic participation.

- Leveraging with non-DOE funds.
- Impacting the solution to DOE problems.
- Gaining user and regulatory acceptance of new technology.

1.6 Taking Actions

The following approach is being used to organize teams around the five focus areas.

Focus Area	Action	Program Execution	Lead Organization
High-Level Waste Tank Remediation	Activate Management and Implementation Teams	FY 1995	DOE Laboratory System
Contaminant Plume Containment and Remediation	Activate Management and Implementation Teams	FY 1995	DOE System
Mixed Waste Characterization, Treatment, and Disposal	Activate Management Teams	FY 1995 [Manage implementation through existing system]	To be determined no later than 3/95
Landfill Stabilization	Active Management Teams	FY 1995 [Manage implementation through existing system]	To be determined no later than 3/95
Facility Transitioning, Decommissioning, and Final Disposition	Activate Management Teams	FY 1995 [Manage implementation through existing system]	To be determined no later than 3/95

The actions and milestones shown in Table 1.1 describe a fast-track course for implementing the new approach to environmental research and technology development within DOE. The actions shown in Table 1.1 will be implemented under the direction of the Steering Committee once this plan and schedule are approved by EM-1.

Table 1.1 Major Activities and Milestones

Action/Milestone	Date
1. Complete Draft Action Plan	January 7, 1994
2. Activate Steering Committee	January 14, 1994
3. Establish Steering Committee Support Team	January 14, 1994
4. Complete Briefing Package for S-1	January 14, 1994
5. Conduct Briefing to EM-1 on "A New Approach"	January 24, 1994
6. Conduct Briefing to S-1 on EM Strategic Plan	January 25, 1994
7. Conduct Planning for Focus Area Management Teams - Contaminant Plume Containment and Remediation - High-Level Waste Tank Remediation - Mixed Waste Characterization, Treatment, and Disposal - Landfill Stabilization - Facility Transitioning, Decommissioning, and Final Disposition	January 26-27, 1994
8. Conduct Kick-Off Meeting for All Focus Area Management Teams	January 28, 1994
9. Finalize and Distribute Action Plan via Memo from EM-1	February 1, 1994
10. Establish the DOE National Environmental Science and Technology Council	February 8, 1994
11. Issue Guidance Memo to Operations Offices on Site Technology Coordination Groups	February 8, 1994
12. Submit Standardized Outline of Strategic Plans to Steering Committee	February 15, 1994
13. Submit Standardized Outline of Management Plans to Steering Committee	February 15, 1994
14. Complete Strategic Plans for Focus Areas	April 1, 1994
15. Issue Calls for Interest and Qualifications for Two Focus Area Implementation Teams - Contaminant Plume Containment and Remediation - High-Level Waste Tank Remediation	April 1, 1994
16. Submit Proposals for Two Focus Area Implementation Teams	May 1, 1994
17. Submit Management Plans for Focus Areas to Steering Committee	May 1, 1994
18. Select Lead Organizations for Two Focus Areas - Contaminant Plume Containment and Remediation - High-Level Waste Tank Remediation	May 13, 1994
19. Submit Site Technology Coordination Plans from Operations Offices	June 1, 1994
20. Submit Draft Implementation Plans - Contaminant Plume Containment and Remediation - High-Level Waste Tank Remediation	July 8, 1994

Action/Milestone	Date
21. Submit Final Implementation Plans - Contaminant Plume Containment and Remediation - High-Level Waste Tank Remediation - Mixed Waste Characterization, Treatment, and Disposal - Landfill Stabilization - Facility Transitioning, Decommissioning, and Final Disposition	August 2, 1994
22. Issue Initial FY 95 Guidance and Approved Funding Program for all Focus Areas	August 10, 1994
23. Decide Whether Lead Organizations Will be Used for Remaining Implementation Teams - Mixed Waste Characterization, Treatment, and Disposal - Landfill Stabilization - Facility Transitioning, Decommissioning, and Final Disposition	NLT March 1995

2.0 Contaminant Plume Containment and Remediation

This section provides an example of the new approach described in Section 1.0 applied to the containment and remediation of contaminant plumes. The mission of the Contaminant Plume Containment and Remediation Focus Area[a] is to identify and develop cost-effective solutions for plume remediation problems, within the time constraints dictated by DOE as the Department implements remediation measures in response to regulatory requirements. The Contaminant Plume Focus Area will promote the following objectives:

- Partnership with the private sector to accelerate the transfer of industrial cleanup capabilities to DOE sites and the transfer of DOE-sponsored technologies to the U.S. and global environmental marketplace.

- Accelerated interactions with other DOE program elements, particularly ER, to facilitate the transfer of emerging research concepts that may lead to new technology breakthroughs.

- Leverage of the ongoing and extensive environmental research and development taking place at universities with the DOE program.

The technical scope of this focus area includes all contaminants that are dispersed in surface soils, ground water, and the vadose zone. As illustrated in Figure 2.1, this includes contaminant plumes introduced into the subsurface by aerosol deposition, leakage, or seepage from waste disposal/storage facilities, and underground injection. It does not include containment or excavation of contaminants within the confines of engineered landfills or tanks, both of which are covered by other focus areas. Plumes resulting from these releases contain solvents, fuels, metals, radionuclides, organic compounds, non-metallic inorganic compounds, and mixtures of these constituents. Efforts of the Plume Focus Area will be closely coordinated with the Landfill Stabilization, High-Level Waste Tank Remediation, and to some extent, the Mixed Waste Focus Areas.

The Contaminant Plume Focus Area will develop technologies needed to support all of the activities illustrated in Figure 2.2. These include characterization and monitoring of contaminant plumes, plume risk management options (no-action, containment, and remediation), economic analysis, and risk assessment. For this report, the following definitions will be employed:

No action: No intervention measures are taken to control or remove the plume. However, this option includes monitoring the status of the contaminant plume, quantifying the extent to which natural processes alter the contaminant distribution over time, and possibly using institutional controls to limit exposure.

[a] The Contaminant Plume Containment and Remediation Focus Area is abbreviated in the text as the Contaminant Plume Focus Area.

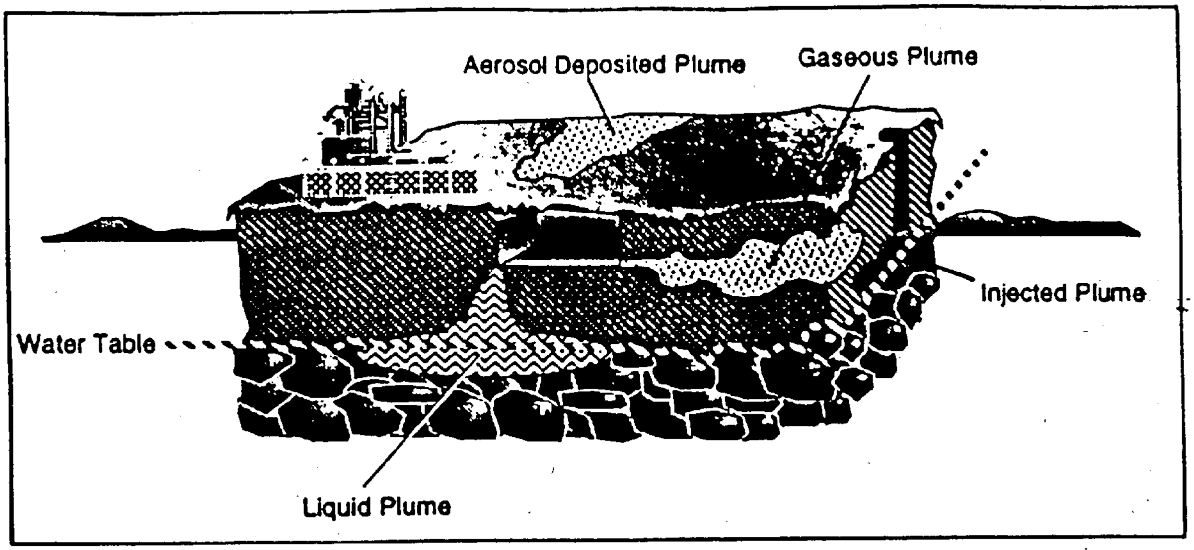

Figure 2.1 Plumes are Defined as Unwanted Contaminants that are Dispersed in Surface Soils, Ground Water, or the Vadose Zone. Contaminants in Source Areas such as Storage Tanks or Landfills are not included.

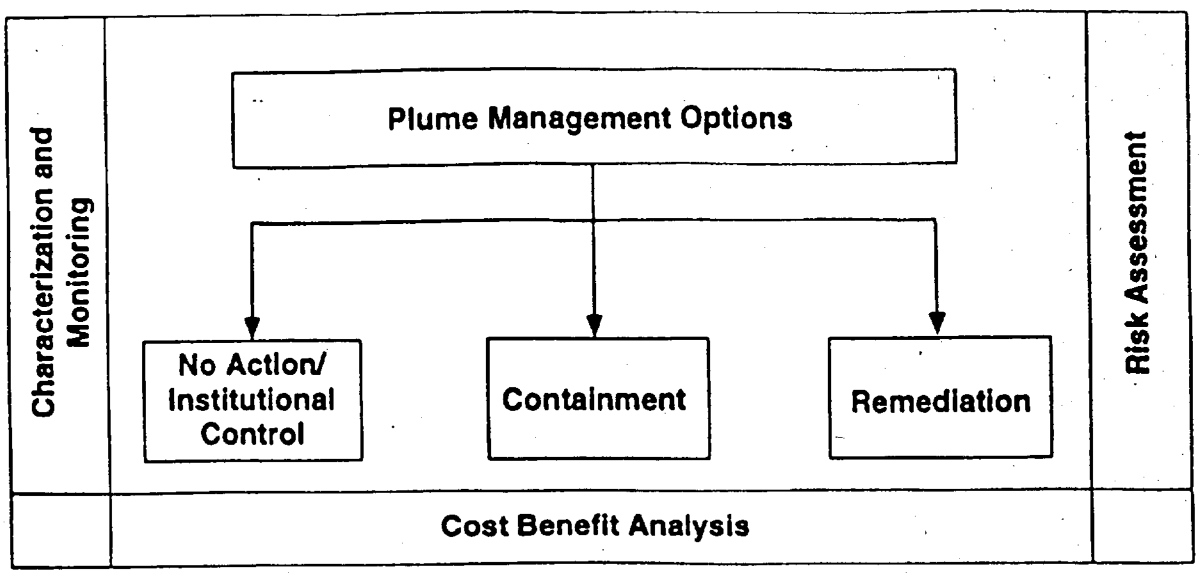

Figure 2.2 Schematic showing the major activity required to support the Plume Focus Area.

Containment: Further migration of a contaminant plume is controlled by implementing engineering solutions. Institutional controls may also be used to prevent human intrusion into the contaminated media.

Remediation: Contaminants are removed or converted to non-hazardous chemicals to make the environment suitable for uncontrolled or partially controlled beneficial use.

Note that risk assessment is not addressed specifically in this report. Other teams within EM are developing a risk assessment program that will be coordinated with the Contaminant Plume Focus Area. However, the methodology required to assess potential exposures to contaminants through subsurface pathways is included in the other activities described herein.

The Contaminant Plume Focus Area will maintain cognizance of the state-of-the-art in all of the activities illustrated in Figure 2.2 and will focus technology development efforts to provide the greatest potential improvements. This effort will include maintaining a repository of information that will be available to customers and stakeholders.

Plume remediation is among the most difficult problems faced by DOE, and the technological state-of-the-art is sometimes quite primitive and costly. To address these challenging problems, the Contaminant Plume Focus Area will invest in a portfolio of technologies based on the near-, mid-, and long-term strategies described in Table 2.1.

2.1 Situation Analysis

Contaminant plumes have existed at DOE sites for over 30 years. Whereas the extent of individual plumes has been characterized and monitored for many years, only recently have attempts been made to contain or remediate specific plumes. Experience gained over the years indicates that the technology program must address a number of issues to be successful: difficulty in linking problem holders with solution providers, lack of clearly defined cleanup goals and technologies to achieve these goals, unresolved technical issues specific to development of technology for site characterization and for plume containment/remediation, and difficulty in focusing and prioritizing problems for technical solutions.

2.1.1 Customer Definition and Requirements

To implement a focused problem-driven technology development program, both the EM Headquarters customer and the site customer must adequately describe and prioritize the problems within the site and within DOE that require technology- or science-based solutions. The site customer takes the lead in defining the nature of the problem, identifying sources of usable technology for solving the problem, identifying any technology deficiencies, and implementing remedial solutions at the site within appropriate DOE and regulatory guidelines. The site customer maintains the option of selecting the most appropriate technology from either internal or external sources at the time of the remedy selection. The EM Headquarters customer is responsible for setting technology development policy, as well as prioritizing and integrating technology development needs across the entire DOE complex.

Table 2.1 Strategy of the Plume Focus Area Program in Near-, Mid-, and Long-Term

Time Frame	Action	Expected Benefit
Near-Term 0-3 years	• Work with site customers and industry to adapt emerging technologies for application to the DOE complex. • Increase resources for promising plume containment technologies to accelerate their implementation at DOE sites.	• Fast-track implementation of emerging containment and remediation technologies. • Reduce continuing contaminant releases over increasingly wide areas, which will reduce environmental risks, and will cut mid- and long-term costs while advanced technologies are being developed.
Mid-Term 0-5 years	• Continue developing new remediation and characterization technologies (in that priority order), exploiting progress made from the existing integrated programs and demonstrations. • Seek reviews by industry and research groups, establish collaborative research and development, and accelerate technology transfer.	• Maximize results from existing programs and strengthen basic research involvement, which will lead to technology breakthroughs at intermediate-scale contaminated DOE sites.
Long-Term 0-10 years	• Invest in directed research likely to result in significant scientific or technological breakthroughs to improve the success of plume remediation. • Coordinate these efforts with ER basic research programs, other Federal programs, and university research and development programs.	• Ensure the availability of new strategies or technologies for plumes for which there are no available remediation technologies and remediating large plumes (hundreds of km^2). • Develop a coordinated, basic, and directed Federal research and development program on plume remediation technologies.

Customer requirements for plume remediation technology are often highly site specific. To be successful, technology development must be responsive to site-specific considerations such as local geologic and hydrological conditions, state and local regulations, local stakeholders' concerns and values, and plans for future land use. To ensure that new technologies can be implemented and that site customers are aware of new developments, technology developers must maintain close contact with site customers.

2.1.2 Problem Description

With the exception of radioactive materials, contaminants on DOE lands are the same ones associated with common industrial practices found throughout the country -- solvents, fuels, salts, organics, and metals. Over 3700 individual release sites have been identified on DOE lands. Plume remediation efforts are expected to continue for at least 30 years and present a major scientific and technical challenge.

Types and Sources of Contaminant Plumes

Analysis of DOE site problems has identified six major categories of contaminants: 1) volatile and semi-volatile organic compounds (VOCs), including solvents and fuels; 2) salts, e.g., nitrate; 3) heavy metals; 4) tritium; 5) radionuclides; and 6) mixtures of organic compounds, radioactive elements metals, and salts. Contaminants within all of these classifications are potential or known carcinogens or above certain concentrations can otherwise adversely affect human health and reproduction.

Important sources of contaminant plumes at DOE sites include the release to the soil of aqueous solutions of contaminants (e.g., seepage basins, cribs, leaking tanks, and landfills); release to the soil of volatile liquids that vaporize in the subsurface and migrate in vapor form through the vadose zone, dissolving in ground water when contacted; airborne releases that are deposited on the soil surface by wind or precipitation; wells used for underground injection of wastes; and waste disposal areas containing contaminants that are mobilized by precipitation, ground water, or surface water moving through the site. As a result of these releases and past waste disposal practices, contaminants are found in surface soils, the vadose zone, and ground and surface waters at DOE sites.

Major Obstacles to Plume Remediation

The following major challenges to plume remediation have been identified based on existing experience within the DOE complex and elsewhere. It is anticipated that new challenges and priorities will be identified by DOE site and Headquarters customers as a result of the new approach.

Characterization of the Nature and Extent of Contaminant Plumes: The traditional means for locating contaminant plumes relies on soil and ground-water sampling and subsequent chemical analysis. Because of the time and expense of installing wells, collecting soil samples, and analyzing laboratory samples, site characterization is both time-consuming and expensive. Moreover, even after an extensive site characterization effort, uncertainty may remain regarding the detailed distribution and chemical forms of the contaminants. Innovative techniques must be developed for more thoroughly, quickly, and cheaply characterizing plumes.

To improve our ability to characterize plumes, it is also essential to find more rigorous methods for integrating different forms of characterization data (called data fusion) and interpolating between sampling points. Data fusion and interpolation techniques include statistical methods, three-dimensional visualization, and integration of fate-and-transport models with site contaminant and geophysical data. Improvements in all these areas are needed for more effective plume remediation.

Remediation of Aquifers Contaminated with Non-Aqueous Phase Liquids: Pure phase (undiluted) liquids, usually organics, that have low solubility in water are common sources of contaminant plumes at DOE sites. Those that are lighter (less dense) than water are called "light non-aqueous phase liquids," or LNAPLs. Gasoline, toluene, and kerosene are typical LNAPLs. Low-solubility liquids denser than water are referred to as "dense non-aqueous phase liquids," or DNAPLs. Polychlorinated biphenyls, mercury, and chlorinated solvents, such as trichloroethylene, perchloroethylene, and carbon tetrachloride are typical DNAPLs.

The water table tends to stop the downward movement of LNAPLs, and these are often seen as a separate phase in ground-water samples. Hence, LNAPLs tend to be more easily detected and are therefore more easily remediated. DNAPLs, however, are not as easily detected, characterized, and remediated with current technology. They tend to sink into the saturated zone and spread laterally above low-permeability strata. They can also be trapped in weathered or fractured bedrock and have even migrated "up-gradient" (i.e., opposite the direction of ground-water flow). Detection of DNAPLs will greatly assist in plume remediation. Currently, the presence of DNAPLs is inferred by detecting concentrations that approach their solubility limit in water.

Small volumes of DNAPLs can give rise to large contaminated ground-water plumes with concentrations far above acceptable health-based standards. Because DNAPL pools may take hundreds of years to be released, aquifer remediation by ground-water pumping is now being realized as largely unsuccessful in meeting cleanup levels in a reasonable timeframe. Moreover, it is seldom practical to attempt to permanently remediate a ground-water plume by only remediating the plume itself. The primary source of contamination must also be removed, contained, or otherwise controlled. Secondary contaminant sources that lead to "recontamination" must also be contained or remediated, including areas where contaminants have adsorbed onto soil particles and natural organic matter (organic and inorganic contaminants). Contaminants may be desorbed from these sources long after the primary source has been removed, extending the life of the plume. Removal of materials adsorbed onto organic material and clays can be very slow. Further research and development work on the basic fluid chemistry, interaction between the contaminant and the solid matrix, and transport processes is required for more reliable predictions and optimization of remediation efforts.

Remediation of Aquifers and Soils Contaminated with Heavy Metals, Radionuclides, and Mixed Waste: Inorganic contaminants, such as heavy metals and radionuclides, often undergo complex chemical and microbial interaction with the geologic host materials that thwart aquifer remediation attempts. Reactions that may transform the contaminant into species with different toxicities and mobilities include hydrolysis, oxidation, reduction, and neutralization. The rate of these reactions depends on the chemistry of the ground water and the aquifer matrix (e.g., pH, acidity/alkalinity, redox potential, dissolved salts, and the types of organisms present). Each of the above reactions, and other reactions, may occur as spontaneous chemical reactions or be catalyzed through biotransformations. The scientific foundations underlying the processes and heterogeneity in subsurface systems are poorly understood, making it difficult to predict migration rates and potential human health or ecological risks. Moreover, the limited solubility and mobility of many of these contaminants make it difficult to flush them from the subsurface.

Determining the Risk to Human Health and the Environment: Decreasing risk to human health, ecosystems, and natural resources is a primary motivation for plume containment and remediation. Actions are most urgent when ground-water supply wells are threatened or sensitive ecosystems are at risk. Ground-water plumes reaching surface water bodies can also threaten human health through ingestion, inhalation of dissolved volatile species, or skin absorption and can threaten susceptible plant and animal populations. The effectiveness of remediation actions must be evaluated by the extent to which risks are minimized or controlled. Methods for evaluating risks to the exposed populations include modeling fate and transport of contaminants, assessing exposure and dose, and evaluating resultant health effects. The risk to remediation workers must also be evaluated when selecting remediation options. Risk-based cleanup standards based on future land use could assist these efforts. Because public perception of risk can sometimes differ from scientific analysis, stakeholder and public involvement is essential at all stages of the remediation planning and implementation process.

2.1.3 Scientific and Engineering Foundations

The scientific and engineering foundations for plume remediation are described below.

Geosciences and microbiology expertise is required to understand and describe the terrestrial, hydrologic, and atmospheric processes that control the chemical, physical, and biological subsurface environment. Detailed knowledge of the geologic and hydrologic setting, which introduces complex physical, chemical, and microbial heterogeneities that frustrate plume remediation, provides the framework for evaluating plume migration processes.

Subsurface fate and transport expertise is required to understand and predict the physical, chemical, and biological processes in soils, vadose zone, and ground water that result in stabilization and/or in mobilization by bio-geochemical transformations of contaminants, and control successful in situ remediation.

Chemical and microbiological expense for surface and subsurface treatment is required to develop methods to treat contaminants in the subsurface or waste streams that are brought to the surface.

Surface and subsurface measurement systems expertise is required to develop technologies used to interrogate the subsurface, either directly or remotely, to provide information about the subsurface physical, chemical, and microbial environment.

Computation expertise is required to develop mathematical models for performing complex calculations of contaminant migration and reactions in the subsurface, to develop real-time monitoring systems, to visualize three-dimensional subsurface structures and plume data, to perform statistical analysis of data sets, and to optimize process or engineering parameters.

Process and subsurface engineering expertise is required to design surface treatment systems, extraction and injection wells for subsurface remediation, and subsurface barrier systems for containment.

2.1.4 Current State of Technology

The current technologies for assessing the nature and extent of containment plumes and for evaluating risk management options are illustrated in Figure 2.3 and discussed briefly below.

Plume Characterization Technology: Characterization and monitoring of a contaminated site forms the basis for decision-making and will continue until regulatory agencies and agreements no longer require it. Plumes of contaminants are characterized by extensive collection and chemical analysis of soil and ground-water samples. Samples are subdivided by depth interval to obtain information on the three-dimensional plume distribution. Soil samples typically are collected with hand or mechanical augers and push tubes. Sampling techniques for plume delineation in the saturated zone employ a variety of borehole sampling devices

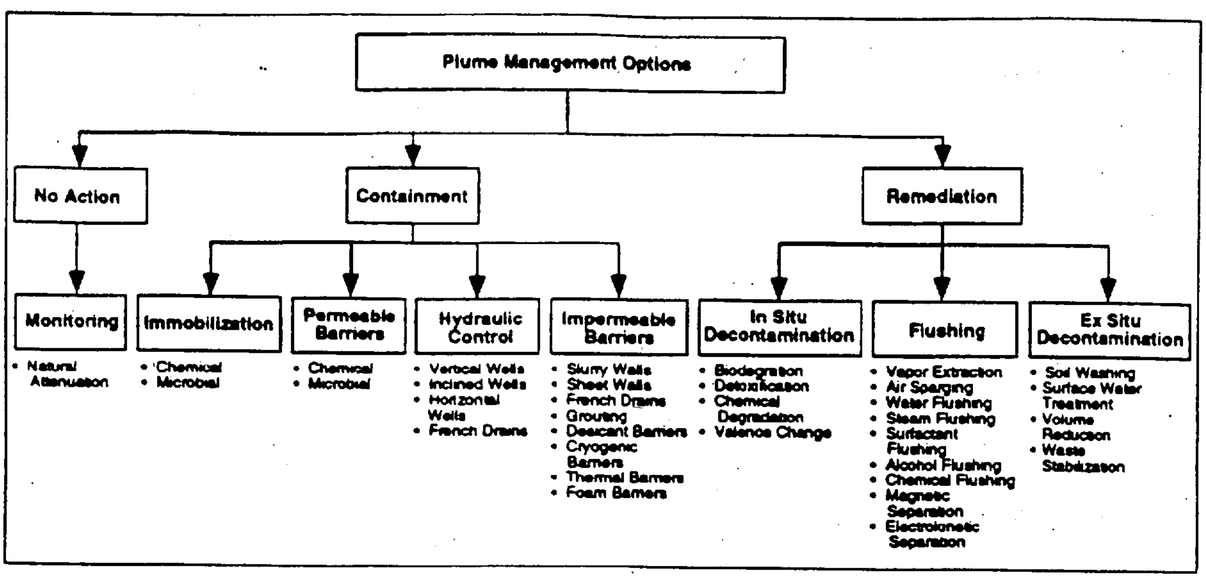

Figure 2.3 Schematic Showing General Categories of Actions for Remediation of Contaminant Plumes

such as standpipe piezometers, multilevel samplers, and packer arrangements. Additional vadose zone characterization and monitoring technologies include suction lysimeters, and for certain VOCs, soil gas samplers. All of these plume characterization and monitoring techniques are flawed by their low spatial resolution, and because of their intrusive nature, their generation of potential pathways for further migration of contaminants. Recently, the cone penetrometer has been demonstrated as a very effective tool for rapidly locating some forms of organic contaminants. Non-invasive or minimally invasive electromagnetic or seismic imaging technologies are also useful for delineating contaminant plumes and interpolating between sampling points.

Technology to Support the No-Action Option: Following the characterization phase, it may not be necessary to implement measures to contain or restore the contaminated media. In such cases however, it is prudent to monitor the status of the plume and to assess the extent to which natural attenuation alters the extent and chemical characteristics of the plume. Technologies for monitoring plumes and assessing natural attenuation processes are essentially identical to those used for characterizing the plume. However, additional interpretation of these data may be required to identify changes in the location of the plume and the contaminant mass contained therein. Application of fate-and-transport and risk assessment models can also assist in interpreting these data and provide continued support to the no-action option. In some cases, special measurements may be obtained for identifying by-products of contaminant degradation.

Plume Containment Technology: Two primary strategies are used to contain contaminants: hydraulic containment and impermeable barriers. Developmental technologies for containment, relying on microbial or chemical processes, are listed in Figure 2.3.

Hydraulic containment relies on reversing the hydraulic gradient to prevent further migration of a plume. Reversing the hydraulic gradient can be achieved by pumping a sufficient quantity of water out of an aquifer using appropriately placed wells or by installation of subsurface drains. If the water removed from the aquifer is contaminated, measures must be taken to safely treat and dispose of this waste water.

Impermeable barriers are often used to cap a contaminant source or isolate it with vertical walls. Common methods for capping include a combination of low-permeability natural materials such as clay and synthetic textile materials. Impermeable vertical barriers are commonly constructed by grout injection through vertical wells or construction of slurry walls. Developmental technologies for creating impermeable barriers also listed in Figure 2.3. Additional methods of plume containment that are under investigation include chemical and microbial immobilization technologies and the use of reactive, inorganic, permeable barriers.

Plume Remediation Technology: The primary technology used to remediate ground-water plumes is pump and treat. However, for the reasons outlined in Section 2.1, this method is usually not effective in reducing contaminant concentrations to regulatory standards within the timeframe required by DOE. Several decades of experience have confirmed this, and alternative strategies are required to remediate contaminated aquifers in a reasonable timeframe.

Demonstrated and emerging technologies for plume remediation fall into the three broad categories shown in Figure 2.3: in situ decontamination, flushing, and excavation followed by ex situ decontamination or waste disposal. In situ decontamination requires employing chemical or biological processes that degrade or detoxify the contaminant in place. Examples include valence reduction to immobilize and detoxify inorganic contaminants or biodegradation of chlorinated/non-chlorinated organic compounds into innocuous constituents. In contrast, ex situ decontamination involves removal of contaminated materials and treatment at the surface. Excavation and ex situ decontamination are rarely practical for large and deep plumes. Flushing requires mobilization and removal of the contaminants and subsequent waste treatment at the surface. In some cases, flushing and in situ decontamination occur simultaneously.

Several flushing technologies have been developed recently for remediation of plumes of organic contaminants. Vapor extraction is the most commonly employed method for flushing volatile organic compounds from the vadose zone. Bioventing, which combines vapor extraction with oxygen-enhanced biodegradation, has also been successfully employed in the vadose zone. For contamination below the water table, air sparging has been employed with limited success. Several recent demonstrations of steam injection have been effective in flushing large quantities of fuels from the vadose zone, and to a lesser extent, from ground water. The use of surfactants to enhance solubility of contaminants for removal has been evaluated at the bench scale. Field demonstrations are being implemented to evaluate control and removal efficiencies for mobilized contaminants including DNAPLs.

In situ bioremediation, particularly biostimulation of indigenous organisms by nutrient amendments, has been successful at shallow depths and for organic chemical degradation in particular. The release of genetically engineered microbiota, despite encouraging scientific developments, will continue to be limited in the future by regulatory restraints and technical impediments such as limits in predicting bacterial transport in situ. Biostimulation in situ is limited by a lack of knowledge of the distribution and processes that control the presence, abundance, and diversity of natural populations which influence bioremediation in some contaminated areas. Knowledge is also sparse regarding the microbial population in mobilizing or stabilizing complexed radionuclides. Although in situ bioremediation will contribute in time to the clean up of deep aquifers (which may be impossible to clean up using existing in situ method), its application for plume remediation is necessarily long-term pending advances in basic research. Other developmental techniques are also listed in Figure 2.3.

Soil, vadose zone, and ground-water plumes will remain a major issue to DOE for decades, and much work is needed. Examples of technical developments needed to provide solutions for the Contaminant Plume Focus Area are listed in Table 2.2.

Table 2.2 Examples of Technology Needs for Plume Remediation

Category	Technical Needs
Characterization and Monitoring	• In situ, real-time characterization tools • New soil and ground-water sampling and monitoring methods • Improved fate and transport models • New data fusion methods • Advanced non-invasive characterization methods • Improved sensors and methods for chemical analysis
No Action/Institutional Controls	• Better understanding and models of fate and transport processes • New monitoring and characterization techniques (see above) • Development of special techniques for monitoring degradation or transformation of contaminants
Containment	• New materials for constructing physical barriers • Improved understanding of in situ chemical and microbial transformation processes • Chemical and microbial immobilization methods • New barrier emplacement technology • Methods for three-dimensional encapsulation of contaminants • Better methods for optimizing performance of hydraulic barriers • Permeable barrier systems
Remediation	• Better understanding of contaminant interaction with geologic materials • Improved fate and transport models • New methods for mobilizing contaminants in geologic materials • Improved methods for bioremediation and in situ nutrient and treatment delivery • New engineering design and decision support tools for optimizing flushing and decontamination schemes • New methods for in situ decontamination • New methods for DNAPL restoration • New methods for remediation of mixed waste

2.1.5 Current Plume Technology Development Programs in EM

The EM has extensive technology development projects related to the Contaminant Plume Focus Area within EM-50 (see Table 2.3) and EM-40 (see Table 2.4). EM-30 also conducts significant related efforts at the Waste Isolation Pilot Plant (WIPP) site. The total investment by EM-50 in plume technology development in FY 1993 was about $60 million, and about $65 million was spent in EM-40.

Table 2.3 EM-50 FY 1994 Plume Technology Development Activities

Program	Activity	Location	Purpose
Volatile Organic Compounds (VOCs) in Non-Arid Soils	Integrated Demonstration	Savannah River Site, Aiken, SC	Develops, demonstrates, and compares technologies to characterize, remove, destroy, and monitor VOCs in soils and ground water at non-arid sites.
VOCs in Arid Soils	Integrated Demonstration	Hanford Operations, Richland, WA	Develops, demonstrates, and compares technologies to characterize, remove, destroy, and monitor VOCs in soils and ground water at arid sites.
In Situ Remediation Technology	Integrated Program	Activities to support sites across the DOE complex	Research and development on the treatment in place of contaminated soil and ground water and the containment of contaminants to prevent their spread.
Characterization, Monitoring, and Sensor Technology	Integrated Program	Activities to support sites across the DOE complex	Develops new and improved site characterization and waste treatment monitoring technologies.
Dynamic-Stripping	Project	Lawrence Livermore National Laboratory, Livermore, CA	Conducts rapid cleanup of gasoline spill, reducing remediation time from decades to months.
Supercritical Water Oxidation	Program	Idaho National Engineering Laboratory, Idaho Falls, ID	Demonstrates a system to remediate DOE complex-wide mixed and hazardous waste using supercritical water oxidation.
Mixed Waste Landfill	Integrated Demonstration	Sandia National Laboratories, Albuquerque, NM	Demonstrates, tests, and evaluates characterization and stabilization cleanup technologies for soils contaminated with volatile and non-volatile organics, metals, and radionuclides.
Resource Recovery	Project	Butte, MT	Demonstrates recovery of heavy metal contaminants from water with the resulting production of marketable resources.
Uranium Contaminated Soil	Integrated Demonstration	Fernald Environmental Management Project Fernald, OH	Develops cost-effective system to remediate low levels of uranium contamination over large areas.

Table 2.4 The FY 1993 Summary of Environmental Restoration (EM-40) Plume Remediation Technology Development Programs

Category of Plume Remediation Technology	Funding ($M)	Purpose
Characterization	21	• Sonic drilling • Fate and transport modeling • Field sampling techniques • Construction of nested deep wells • Deep well construction • Non-reactive grout for sampling well construction • Geophysical monitoring • Chemical characterization of actinide contaminants • DNAPL characterization
Containment	8	• Chemical barriers • Capping methods • Biofiltration barriers
Remediation	39	• Surface waste treatment for VOCs • Soil washing for actinides • Volume reduction of contaminated soils • Vapor evacuation • Steam stripping for mixed waste • Treatability studies • Waste stabilization • Bioremediation of diesel fuel • DNAPL remediation • Steam stripping for gasoline

Plume Characterization and Monitoring Technology: Technology development programs in EM include innovative drilling and sampling techniques, improved construction techniques for ground-water monitoring wells, geophysical methods to locate and characterize plumes, improved methods for DNAPL detection, sensor systems for real-time in situ monitoring of contaminant concentrations, and characterization of the chemical status of actinides in soil.

Technology to Support the No-Action Option: All of the characterization and monitoring technologies described previously can be used to monitor the fate and transport of chemical plumes where no actions have been implemented to control migration or resolve the media. Natural chemical and microbiological attenuation processes that can contribute to gradual reduction in contaminant concentrations are not being investigated by EM; however, scientists in the Office of Health and Environmental Research (OHER) Subsurface Science Program, which is described later in this section, are carrying out basic research that contributes to our understanding of these processes. Results of these investigations need to be incorporated into risk analysis models to support the no-action option.

Plume Containment Technology: The EM is improving or developing a number of different containment technologies, including flow-through or permeable barriers that strip the contaminants from ground water, chemical barriers that immobilize radioactive and mixed waste contaminants, enhanced capping technologies, methods to create underground horizontal barriers through inclined or horizontal wells, and innovative materials to encapsulate contaminants that perform more reliably than conventional grouts. The EM is developing containment technologies in the majority of categories listed in Figure 2.3.

Remediation Technology: The EM is developing a number of technologies to flush volatile and semivolatile organic compounds from the vadose zone and ground water. These include horizontal wells for enhanced vapor extraction and air sparging, foam and surfactant flushing, steam flooding, and heating using resistive and bio-frequency methods. In addition, technology for nutrient-enhanced biodegradation of solvents is also being developed. Technologies for treating remediation-generated waste streams are being developed, such as supercritical water oxidation for organics and metal recovery from inorganic waste. Other remediation technologies under development, including electrokinetic migration, soil washing, surface treatment, and magnetic separation, are listed in Figure 2.3.

2.1.6 Needed Technology Thrusts

While improvements in nearly every aspect of plume remediation are possible and desirable, due to limited resources, the environmental technology development effort must be focused on a limited number of high-priority problems to effectively overcome major obstacles to plume remediation. As described in Table 2.1, a portfolio approach, which balances near-, mid-, and long-term priorities will be implemented. The program will be initiated by evaluating existing integrated programs and demonstrations but is expected to evolve as customer needs are prioritized. For example, we anticipate a greater short-term emphasis on development and improvement of containment technologies.

Near-term priorities are two-fold. First, the program must improve customer involvement, particularly with regard to site-specific adaption of technology through industry vendors. Second, improvement and development of plume containment technologies will be accelerated. Justification for this increased emphasis on plume containment includes the following:

- Containment technologies are more broadly applicable to all categories of DOE containments, unlike remediation technologies which are highly contaminant and site specific.

- Within a short timeframe, it is more likely that successful plume containment technologies can be developed than remediation technologies.

- Once the contaminants have been contained, more time will be available to develop and improve remediation technologies.

In the mid-term, important considerations in priority setting also include the volume and aerial extent of contaminants within the DOE complex, the progress of industry and other Federal agencies working on similar problems, and the risk to public health and environment. Given these considerations, the major problem areas to be addressed are remediation of VOCs in the vadose zone, VOCs in ground water, heavy metals, DNAPLs, radionuclides in ground water, and mixed waste contaminated soils. Significant progress in characterization, containment, and remediation technologies in these areas has been made by the existing EM program. These efforts will be enhanced by more comprehensive reviews and collaborative efforts with industry and extramural research groups. With the exception of radionuclides and mixed waste contaminated soils, these are the same contaminants that plaque many industries throughout the United States. Enhanced industry capabilities in these areas will provide increased economic benefits to this segment of the economy.

For the long-term, priority will be given to a directed research program focused on areas likely to achieve significant scientific or technological breakthroughs in plume remediation. This effort will be coordinated closely with the OHER and Basic Energy Sciences (BES) programs described in Section 2.3.3.

2.2 Management Approach

2.2.1 Organizational Structure and Roles

The organizational structure and roles for the Contaminant Plume Focus Area will follow the model presented in Section 1.3. The Management Team consists of 1) technology developers (primarily EM-50 program managers), users (primarily from EM-40), and field representation from sites with primary remediation problems and 2) membership from other DOE programs (ER, EE, and DP), other agencies (EPA and DoD), the private sector and stakeholders. Program managers for characterization, containment, remediation, and related technology development program will also participate.

To avoid replication of efforts and to ensure that the best possible solutions will be available to the prioritized DOE problems, this focus team will coordinate its efforts with all the other focus areas and coordinate very closely with the Landfill Stabilization and High-Level Waste Tank Remediation Focus Areas. It will also consider the alternatives possible to its customers and adjust its efforts as appropriate to provide desired performance and benefits to its customers.

The Implementation Team requires a Lead Organization with capabilities in plume characterization, fate and transport modeling, remediation, and containment. System-analysis expertise with geotechnical projects that have included data systems, ground-water modeling, and water treatment systems would be likewise valuable. Participation of the Implementation Team would include DOE Laboratories with complimentary capabilities. University and industry participants would be those with capabilities for specific technology development (e.g., sensors for contaminants in ground water, water treatment chemistry, and computational methods for contaminant transport).

2.3 Essential Partnerships and Linkages

Essential to the success of this focus area is the development of partnerships between interested and affected individuals and groups.

2.3.1 Stakeholder Involvement

Technology development activities that address environmental remediation and waste management remediation problems for the Contaminant Plume Focus Area must incorporate involvement of a variety of stakeholders. Stakeholders are those groups or organizations that have a clear, vested interest in the successful outcome of research and development activities designed to address environmental problems. In general, one can identify six types of stakeholders:

- Those who are most directly affected by the site-specific remediation problems that technology development is meant to solve (e.g., members of the public in the vicinity of a site).

- Those who have responsibility for ensuring compliance of remedial measures with applicable environmental laws (e.g., EPA regions, states, and tribes).

- Agencies and public interest groups that have similar plume problems or concerns over contamination. Associations of organizations formed to address ground-water contamination such as the WGA will also be directly involved.

- Those organizations external to DOE that have developed and/or are capable of developing environmental technologies (e.g., research institutions, universities, industry, etc.).

- Those who are responsible for implementation of newly developed or adapted technologies (e.g., the DOE Operations Office, M&O, or ERMC Contractor and subcontractors that are technology users).

- DOE site workers associated with characterization, containment, and/or remediation activities.

2.3.2 Integration Across EM

The Contaminant Plume Focus Area will integrate technology development across EM. In some cases, specific recommendations will be made for program execution; while in others, communication will be established to gain as much supporting technical information as possible. Examples of programs for such interaction include studies of ground-water flow in confined aquifers in the WIPP program; treatability studies for removal of contaminants, stabilization of plumes, hydraulic control, and containment at sites across the complex; integrated demonstrations such as VOCs in arid soil; and wastewater treatment operations. In addition, there will be linkage to other focus areas such as subsequent processing of extracted mixed wastes, which must be addressed in the Mixed Waste Focus Area and the High-Level Waste

Tank Remediation Focus Area. Technology development for plume containment will be closely coordinated with the Landfill Stabilization Focus Area.

2.3.3 Integration Across DOE

To leverage basic and applied funding across DOE, the Contaminant Plume Focus Area will accelerate integration and coordination of the plume-related research and technology development of other DOE offices. For example, ER will be invited to participate in field studies as part of the Contaminant Plume Focus Area through coordination with the OHER Subsurface Science Program, and the BES Geosciences and Chemical Sciences Programs.

The OHER Subsurface Science Program supports basic research in the coupled physical, chemical, and biological processes that affect contaminant mobility, stability, and transformation in heterogeneous subsurface environments and has extensive experience in the field systems in which remediation is needed. Examples of collaboration between EM and the Subsurface Sciences Program include transfer of redox manipulation concepts to the integrated demonstration project at Hanford, Washington. Other opportunities for cooperative field investigations exist. For example, OHER and EM have exchanged ideas on mechanisms to accelerate basic, applied research interactions including "middle ground" field sites to facilitate technology/basic research interactions and to resolve problems in applying new technology in the field. The OHER has proposed to expand its Subsurface Science Program technology transfer workshops that support field bioremediation. The OHER research in subsurface microbiology is the largest in the Federal Government, and is a leader in long-term research in microbial heterogeneity in the vadose and saturated zones, which is important to bringing in situ bioremediation technologies on line.

The BES Geosciences Program focuses on the fundamental aspects of the geophysics, geomechanics, and geochemistry of fluid-rock interactions and has developed tools such as subsurface imaging technologies, which can make near-, mid-, and long-term contributions to field studies at DOE sites. Examples of existing collaboration between EM and the BES Geosciences Program include investigations of radioactive contamination at Chelyabinsk in Russia and monitoring of in situ vitrification of surrogates of radioactive waste at Oak Ridge, Tennessee. Other examples of indirect benefits to EM include the BES Geosciences-sponsored computer code STMV6C, which simulates steam flooding to remove VOCs from the vadose zone and ground water. STMVOC was used to help evaluate the Integrated Demonstration Project at the Savannah River Site and the Dynamic Stripping Project at Lawrence Livermore National Laboratory.

The BES Chemical Sciences Program sponsors basic research on the chemistry of aqueous systems in support of waste management and on molecular-scale data that is necessary for understanding and modeling chemical reactions in mixed waste stream. The Program also conducts basic research in analytical chemistry that provides the basis for development of innovative sensor systems. Basic research on the properties of engineered materials, conducted by the BES Material Sciences Program, contributes the fundamental knowledge needed to develop materials tailored to survive specific waste environments. The BES Energy Biosciences Program supports basic research in plant sciences and microbiology related to contaminant bioaccumulation and degradation of organic chemical contaminants. The capabilities to calculate subsurface flow and transport have been developed by the High-Level Nuclear Waste and Geothermal Programs.

Interactions, such as those described previously, will enhance collaborations at the field scale, and increase cooperation and focused research and development projects. The DOE offices with related research will be invited to identify opportunities for jointly sponsored research and development, to direct basic research and technology development activities, and to assist in developing a strategy for the focus area that includes a strengthening of the role of basic research.

The Advance Drilling Techniques Committee, Fossil Energy, Geothermal, and the commercial Radioactive Waste Programs will participate on committees to identify program needs, developments, and current work in the area of well drilling technology.

2.3.4 External Interactions

Research and technology development efforts are underway within several branches of a Federal government, including EPA, DoD, DOI, and others. Examples of some of the programs are provided below.

The DoD's research and development efforts are conducted by the individual services. The Army Environmental Center coordinates efforts for cleaning up the Nation's army bases. This program funds technology development for weapons cleanup and fuel spills. The Air Force is currently working with DOE on a number of projects in the development of technologies for cleaning up solvents and other contaminants. The Navy has been involved in modifying technologies that it has developed for weapons research for remediation efforts. The Navy also has methods for detection of metals and organics used in surveillance that apply to characterization efforts for buried waste and organic plumes.

The EPA's Office of Research and Development works on technologies for Superfund and other waste sites at various laboratories across the country, and EPA's Technology Integration Office assists in technology transfer to Superfund sites. The EPA has also developed databases that list technologies which are under development as well as industry vendors for remediation work.

The U.S. Geological Survey is developing improved characterization technologies, primarily geophysical techniques that rapidly characterize contaminant plumes, and is also developing fate and transport models.

Specific mechanisms to maintain awareness of related research and identify more opportunities for jointly sponsored projects must be identified. Examples of such mechanisms include the WGA Development of Onsite Innovative Technologies (DOIT) program and inclusion of external agencies on the management team, or ad-hoc advisory teams.

2.4 Metrics for Success

Metrics for the Contaminant Plume Focus Area will be established from the categories provided in Section 1.5. A baseline using existing technology must be established by EM that can be used to evaluate the impact of new technology on the effectiveness and cost of plume remediation.

3.0 Mixed Waste Characterization, Treatment, and Disposal

This section provides an example of applying the new approach to the treatment of mixed waste. The mission of the Mixed Waste Characterization, Treatment, and Disposal Focus Area[a] is to develop, demonstrate, and deliver technologies that are responsive to customer needs and achieve compliance with regulatory requirements for treating and disposing of mixed low-level waste and mixed transuranic waste in a safe, timely, and cost-effective manner. This section sets forth the management and implementation approach for carrying out this mission. This focus area will integrate technology development with other EM activities on strategic planning, deployment of treatment facilities, decontamination and decommissioning, and facility transition.

The Mixed Waste Focus Area will apply a systems approach that considers the total waste management process (i.e., characterization, retrieval, material handling, pre-treatment, treatment, storage, and disposal) including associated regulatory and stakeholder issues. The immediate challenge for mixed waste treatment is to modify existing technologies for near-term application by the customer, especially to address requirements imposed by the Federal Facility Compliance Act of 1992 (FFCAct).

One opportunity to meet the challenge is to build on the WGA initiative, which involves both regulators and stakeholders in developing technology for mixed waste. Through its development of the DOIT Committee's Mixed Waste Working Group, WGA has been instrumental in helping EM develop its mixed waste strategy. The WGA effort could serve as a model for demonstration of innovative technology in the Mixed Waste Focus Area.

The Focus Area will identify applicable baseline technologies, capitalize on opportunities for modifying existing technologies and developing new ones, and pursue technology transfer opportunities to solve major problems for buried and retrievably stored or generated waste, both of which include heterogeneous and homogeneous waste. In this plan, mixed waste will be discussed for three broad classes of wastes: buried, retrievably stored or generated heterogeneous, and retrievably stored or generated homogeneous (Figure 3.1). These classes encompass the finer detailed categories of waste stream and treatability groups that make up DOE's mixed waste. Ex situ treatment systems are emphasized, but in situ treatments are included for buried waste where subsequent ex situ treatment is planned. The program will integrate two thrust areas: 1) technical developments leading to technology and system demonstrations and 2) infrastructure (i.e., the regulatory, stakeholder, and DOE institutional framework), to enable timely implementation of modified or newly developed technologies by the customer.

The EM needs to demonstrate treatment capability quickly to respond to public pressure and the FFCAct schedule. Planned activities for the Mixed Waste Focus Area are designed to

---

[a] The Mixed Waste Characterization, Treatment, and Disposal Focus Area is abbreviated in the text as the Mixed Waste Focus Area.

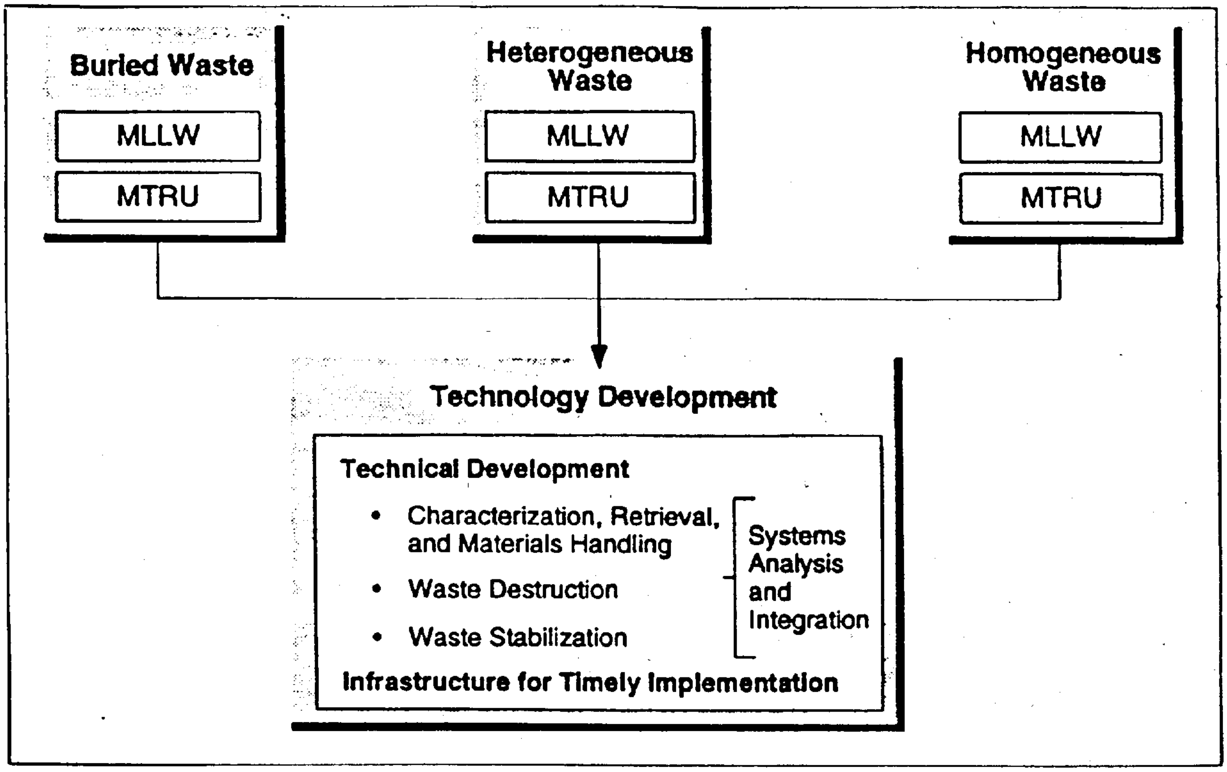

Figure 3.1 Top-level schematic showing general classes of mixed waste and major thrusts for technology development. (Note the terms "heterogeneous" and "homogeneous waste" in this plan refer to retrievably stored or generated waste.)

meet the EM objective to identify major problems and demonstrate progress in a short period of time (see Table 3.1). By building on existing programs, this focus area will start pilot-scale treatment of mixed waste with some technologies in 1 year. The overall goal of this focus area is to have demonstration systems treating actual mixed waste within 3 years.

3.1 Situation Analysis

The DOE will operate all of its facilities, including mixed waste treatment facilities, in full compliance with applicable laws and regulations and will restore inactive sites and facilities so that unacceptable risks to the public or the environment are mitigated. Therefore, DOE is committed and required to treat its mixed wastes; to accomplish safe and timely remediation; to meet milestones established with state governments, the EPA, and in some instances, the U.S. Nuclear Regulatory Commission (NRC); and to meet all applicable Federal (e.g., the FFCAct) and state environmental regulations.

Table 3.1 Mixed Waste Focus Area Planned Outputs

	Planned Output
Immediate (0 to 1 year)	• Development of management and implementation infrastructure involving customer, regulators, and stakeholders for identification of needs and development technologies. • Identification and validation of customer needs and ongoing technology development programs.
Near-term (1 to 3 years)	• Development of field demonstration of technologies for stationary treatment plants/facilities (e.g., closed-loop versatile thermal treatment systems) and for mobile treatment plants for application by small sites for onsite treatment of small-volume waste streams. • Technical assistance and recommendations or treatment options to support the development of site treatment plans required by the FFCAct.
Mid-term (3 to 5 years)	• Further development and demonstration of technologies for treatment plants using innovative technologies and basic research results. • Recommendations for best treatment options for most waste streams based on demonstrated results.
Long-term (5 to 8 years)	• Resource for early stages of facility operation. • Technology upgrades for "next" generation facilities.

3.1.1 Customer Definition and Requirements

Mixed waste technology development has customers at the national program and site levels. The Site Technology Coordination Group represents the site customers to the Mixed Waste Focus Area. The national customers are represented by representatives from the EM offices on the Management Team. In addition, DP is a potential customer through its waste minimization and DOE weapons complex reconfiguration responsibilities. The DoD and the commercial sector (nuclear power facilities, hospitals, academic, and research facilities) also may use DOE mixed waste treatment technologies for their waste streams.

The EM-30 requirements for technology development are:

- Planning, scheduling, recommending, and developing technologies that are responsive to the requirements imposed by the FFCAct (e.g., incorporating technology development schedules in Site Treatment Plans) and by other existing compliance agreements (e.g., Federal Facility Compliance Agreements).

- Providing assistance in identifying specific technology development needs and in obtaining the technical tools, expertise, and resources to determine potential mixed waste treatment options/solutions; examples include identifying baseline technologies for waste streams, developing specific technology to "fill" holes in baselines, and establishing schedule requirements for alternative technologies.

- Applying a systems approach that considers the total waste management process including regulator and stakeholder involvement at an early stage to enhance system acceptability.

The EM-40 mixed waste requirements for technology development are identified during the CERCLA process, which culminates in a Record of Decision (ROD) for soils and ground-water restoration, or facility decontamination and decommissioning activities. The EM-60 mixed waste requirements for technology development will result from facility transition and material deactivation activities.

3.1.2 Problem Description

Mixed waste contains both hazardous constituents governed by RCRA and radioactive contaminants governed by the Atomic Energy Act. The difference between mixed low-level waste and mixed transuranic waste is in the concentration of specific radioactive constituents. Major issues that an EM mixed waste technology development strategy must address include the following:

- There is disagreement over the acceptability of existing proven technologies and their effective implementation in systems to treat a wide diversity of DOE waste streams.

- Federal and state laws and DOE compliance agreements require rapid commitment to plans for schedules, technologies, and facilities for treating mixed waste. Waste minimization measures are also often required.

- Major industry concerns regarding the treatment of DOE mixed waste include the lack of knowledge of market size, of the path for regulatory acceptance once a technology is demonstrated, and of mechanisms for limiting liability.

- Stakeholder input to strategic plan(s) and the decision-making process has been limited.

- The cost of treating and disposing of mixed low-level waste and mixed transuranic waste is estimated in the multi-billion dollar range. This cost provides incentives to develop versatile treatment capabilities that can be standardized to assist with regulatory and public acceptance and that do not require excessive characterization costs for safe and effective operations.

Types and Sources of Mixed Waste

During the next 5 years, the DOE will manage over 1,200,000 m^3 of mixed low-level waste and mixed transuranic waste at 50 sites in 22 states (see Table 3.2); nearly all of this waste will be at 13 sites. More than 1200 individual mixed waste streams exist with different chemical and physical matrices containing a wide range of both hazardous and radioactive contaminants. Their containment and packaging vary widely (e.g., drums, bins, boxes, and buried waste). This heterogeneity makes characterization difficult, resulting in costly sampling procedures and increased risk to workers.

Buried waste arises from past practice and will represent a large fraction of waste from environmental restoration over the next 5 years. Retrievably stored heterogeneous and homogeneous waste arises from past practice and will be generated by future operations. Heterogeneous waste contains mixtures of large amounts of organics, metals, and non-metals, and includes the waste termed, "debris." Homogeneous waste is probably the largest portion of EM-30 waste, contains waste that is principally metallic or non-metallic, and includes liquids and sludges. Special and low-volume waste streams will be addressed within the above classes.

Regulatory Situation

Stored and future generated mixed low-level waste must be treated according to RCRA guidelines covered in FFCAct or in other existing compliance agreements. Stored and future generated mixed transuranic waste must be prepared to meet transportation and waste acceptance criteria (not RCRA treatment). The EM-30 has the responsibility for preparing the DOE response to the FFCAct, which requires that DOE develop plans and schedules for treating its

Table 3.2 DOE-Managed Mixed Low-Level Waste and Mixed Transuranic Waste Volumes

Source of Mixed Waste	Volume (m^3)
Current Site Inventories (EM-30)	
Mixed Low-Level Waste	247,000
Mixed Transuranic Waste	58,000
Operations Generated (5-year Projection)	
Mixed Low-Level Waste	280,000
Mixed Transuranic Waste	2,800
Environmental Restoration Generated (5-year Projection)	
Mixed Low-Level Waste	620,000
Mixed Transuranic Waste	300
Total	1,208,100
NOTE: Information from the Interim Mixed Waste Inventory Report	

mixed waste by October 1995. Additional schedule requirements have been established by other existing compliance agreements (e.g., Federal Facility Compliance Agreements), and in some cases, have shorter deadlines than the FFCAct. Differing state requirements will require negotiations and agreements between the states and DOE. The NGA is providing a forum for states, the EPA, and DOE to discuss FFCAct implementation. The NGA has endorsed the WGA initiative to foster use of innovative technologies and early involvement of regulators and stakeholders in technology demonstrations. The Mixed Waste Focus Group will build on this initiative.

CERCLA governs fixed waste streams that result from soil or ground-water restoration or facility D&D activities. The EM-40 is primarily responsible for CERCLA activities; however, some efforts involve RCRA also. For example, Federal Facility Agreement timetables for restoration activities have been negotiated at all major EM-40 sites.

The EM-60 mixed waste streams result from facility transition and material deactivation activities. While activities are now being identified in a Facility Transition Inventory Report, the detailed waste streams are still undetermined. The EM activities related to radioactive materials are also governed by the Atomic Energy Act through DOE Orders.

The FFCAct requires DOE to meet a constrained schedule to achieve compliance within a complex regulatory situation. Some key issues include the following:

- Regulatory requirements sometimes conflict. RCRA is prescriptive, DOE Orders for implementing waste treatment require interpretation, and CERCLA allows risk-based decisions.

- Major issues have not been resolved, including selection of disposal sites, disposal criteria for radioactive waste, removal of mixed waste from RCRA jurisdiction after treatment, transportation of untreated/uncharacterized wastes to treatment facilities, and use of the debris rule.

- Generally for RCRA-regulated mixed waste, priorities need to be established using a risk-based strategy, to adequately define the risk to the public and workers.

- Existing regulations are performance-based rather than risk-based, and have a built-in bias for acceptance of established, rather than alternative, technologies. In the permitting process, technical issues are often linked to legal, perceptual, or public policy issues; therefore, introducing new technologies is a complex process.

- The needs and priorities of the states may differ from the Federal Government.

3.1.3 Scientific and Technical Foundations

Key technology resources found internal and external to DOE that apply to the Mixed Waste Focus Area include the following:

- The ability to analyze, develop, design, and demonstrate large, complex engineered systems and perform field tests.
- Advanced instrumentation, measurement, and calibration capabilities.
- Sophisticated numerical simulation of systems and processes.
- Specialized material development and manufacturing expertise.
- Physical, chemical, and thermal hazardous and radioactive material processing experience.
- Automated systems, including robotics.
- Risk-assessment capabilities.
- Technical expertise on existing technologies appropriate for the treatment of mixed waste.

Additionally, there are other applicable related capabilities from basic research through development and demonstration within DOE offices (e.g., ER, EE, and DP); government departments (e.g., DoD, DOI, and EPA); and National Laboratories, industry, and academia. Examples of these include ER's basic research programs, DP's nuclear materials processing and waste minimization programs, the extensive industrial experience with hazardous waste processing, the commercial nuclear industry waste experience, and international activities. The existing technology development programs described in Section 3.1.5 and future programs described in Section 3.1.6 will provide a framework to provide key technology resources.

3.1.4 Current State of Technology

Many commercially available hazardous waste treatments, such as vitrification, have not yet been fully developed and demonstrated on actual mixed waste, where the fate of both the RCRA and radioactive species must be fully controlled. Adaptation of existing technologies to handle, treat, and dispose of mixed waste is a major challenge.

Characterization, Retrieval, and Material Handling: Commercial equipment is available for characterization, retrieval, and removal of waste, and for handling containers. However, the heterogeneity of waste is a limiting condition, and containment of radioactive and hazardous constituents during these operations must meet DOE health and safety requirements. Robotic operations are being developed to address these concerns. Commercial non-destructive assay/examination systems are available, but cannot provide the detailed characterization information for large containers required by current regulatory practices. Current capabilities for non-invasive, real-time characterization are not adequate. Cost, analysis time, and risk concerns limit the use of conventional analytical methods.

Waste Destruction: Pretreatment technologies may be required and are generally available (e.g., ion exchange, filtration, evaporation). Additional treatment is required to destroy organics and to stabilize or, where appropriate, to recycle radioactive or metallic or other constituents of the waste subject to RCRA land disposal restrictions. Incineration is applicable for treatment of many mixed waste streams, but it has limited public acceptance. Other thermal processes (e.g., plasma) are being demonstrated for a variety of mixed wastes. These processes offer benefits of direct production of enhanced final waste forms, potentially reduced waste feed characterization, potentially reduced offgas volumes, and the ability to treat a broader array of waste streams. Offgas systems are commercially available for particulate capture, destruction of products of incomplete combustion, and abatement of nitrogen oxides. Current capabilities for process control and monitoring, especially for offgas subsystems, are not adequate for DOE needs. Examples of alternatives to incineration that require development include thermal desorption, molten salt oxidation, various chemical oxidation processes, mediated electrochemical oxidation, advanced wet oxidation, and biological treatments.

Waste Stabilization: Pretreatment may also be required in conjunction with waste stabilization. Grouting is a commonly used process for stabilization of waste. However. the ultimate disposition of grouted waste is highly uncertain due to the lack of disposal requirements or disposal sites. Currently, the volume increase associated with grout (approximately 40%) conflicts with waste minimization policies and makes the final product costly to store or dispose. Vitrification of mixed low-level waste has been demonstrated in bench-scale experiments, is being demonstrated in pilot-scale operations, and builds on in-depth data generated for high-level waste vitrification. Additional enhanced waste stabilization techniques, such as polymer encapsulation and sulfur-polymer cement, are being developed.

Technical Needs

Technical needs for this focus area have been grouped by key functional area and major class of mixed waste in Table 3.3. Some needs identified for a particular technical area and type of waste may also be applicable to others. These needs are based on preliminary customer inputs and EM-50 assessments and consider the full spectrum of mixed waste functional areas. A key early activity of the focus area will be to validate these needs. Major technology gaps include adaption of existing processes to handle radionuclides present in mixed transuranic waste and to handle radionuclides and RCRA hazardous constituents present in mixed low-level waste while processing a wider range in the amount and types of contaminants in the waste stream.

Table 3.3 Technology Development Needs by Functional Area and Waste Class[(a)]

Waste Class Functional Area	Homogeneous Waste: Sludges, Aqueous, and Organic Liquids	Heterogeneous Waste: Debris and Others	Buried Waste (including Contaminated Soils)
Characterization, Retrieval, and Materials Handling	• Statistical characterization of waste streams • Minimal or non-intrusive, risk-based waste stream characterization • Characterize to treat • Risk-reduction	• Drum retrieval • Minimal or non-intrusive, risk-based waste stream characterization • Risk reduction • Efficient waste handling/sorting • Characterize to treat	• Risk-based site characterization • Surgical soil retrieval • Non-invasive real-time monitoring
Waste Destruction	• Concentration • Separations and removal of specific species for subsequent processing • Pretreatment processes such as: - Nitrate/organic destruction - Mercury removal • NO_x-Ammonia destruction • Innovative thermal processes with closed-loop offgas systems • Nonthermal processes with closed-loop offgas systems • Particulate removal • On-line monitoring/control • Mobile Systems	• Decontamination • Mercury removal • Mercury vapor control • Innovative thermal processes with closed-loop offgas systems • Nonthermal processes with closed-loop offgas systems • Particulate removal • On-line monitoring/ control • Mobile systems • Metal reuse	• In situ treatment • Innovative thermal processes with closed-loop offgas systems • Mobile systems
Waste Stabilization	• Concentration • Separations and removal of specific species for waste stabilization • Enhanced, stable waste forms • Waste form testing and performance assessment • Transportation	• Separations and removal of specific species for waste stabilization • Enhanced, stable waste forms • Waste form testing and performance assessment • Transportation	• Enhanced, stable waste forms • Waste form testing and performance assessment • Transportation
Systems Analysis and Integration (Note: This analysis addresses alternative technology subsystems and treatment systems, not macro-level systems analysis.)	• Validated set of customer needs • Project priorities based on needs • Life-cycle costs • Risk assessment • Project integration	• Validated set of customer needs • Project priorities based on needs • Life-cycle costs • Risk assessment • Project integration	• Validated set of customer needs • Project priorities based on needs • Life-cycle costs • Risk assessment • Project integration

[(a)] Note: Waste minimization initiatives are applicable for all technical areas and waste classes in Table 3.3.

3.1.5 Current Mixed Waste Technology Development Programs

The DOE Mixed Waste Inventory Report (MWIR) identified about 270 mixed-waste-related development projects. About 210 of these are in EM-50, while the remainder are principally in EM-30, EM-40, DP, and ER. Other technology development projects within EM could not be identified at that time, but the MWIR updating teams are now identifying many more such projects. For mixed waste, the primary areas for technology development have been identified, the waste treatment (and supporting) technologies around which systems will be designed are relatively small in number, and initial priorities have been established. Additionally, key areas are being identified where DP, ER, and other DOE capabilities, as well as those of industry and academia, can provide for related development or basic research support (examples are noted in Sections 3.1.3 and 3.3.3). This focus area is well positioned to link these key areas to form and execute the Mixed Waste Focus Area.

Table 3.4 lists current EM-50 programs either focused on or addressing aspects relevant to mixed low-level waste and mixed transuranic waste. These programs have established customer involvement in planning, evaluation, and technical strategies; started regulatory and stakeholder interfaces; identified baseline technologies and needs; taken a systems approach; emphasized near-term demonstrations; and emphasized industry and university participation. These programs total about $72 million in FY 1994 and have ongoing or planned activities addressing the high-priority needs in Table 3.3. The emphasis is on treatment for disposal with the final waste form being glass. Development of closed-loop offgas systems and real-time monitoring support all thermal treatment processes (i.e., plasma arc, vitrification, molten metal, and incineration).

The EM-30 supports technology development and demonstrations linked to current site agreements with their host states, EPA, and other concerned parties, which have distinct, enforceable milestones for which technology selections must be made. The milestones may include activities such as permit filing dates, Title I and Title II design delivery dates, and dates for start of construction of treatment facilities. Examples of the many EM-30 existing or planned facilities for mixed waste are listed in Table 3.4. Many of these emphasize incineration and grouting. The technology selections may require performance data for specific waste streams and engineering adaptations of commercially available waste management technologies not yet applied to DOE waste streams. Often these activities support the construction and commissioning of a line-item waste treatment or management facility and are an integrated part of the facility project. The total EM-30 funding on technology development is estimated to be approximately that of EM-50. The EM-40 and EM-60 support technology development activities on the same basis.

Information from EPA, NIST, industry, and industrial foundations such as the Electric Power Research Institute is being assembled to identify ongoing programs relevant to this focus area technology. This information is being compiled into an EM-50 analytical database that will address commercial hazardous or nuclear waste and will include current EM-50 projects focused on mixed waste.

Table 3.4 Current EM 50 Programs and Examples of EM-30 Facilities Focused on Mixed Waste Problems

Current EM-50 Programs
Mixed Waste Integrated Program*
Buried Waste Integrated Demonstration*
Rocky Flats Compliance Program*
Supercritical Water Oxidation Program
Minimum Additive Waste Stabilization*
Mixed Waste Landfill Integrated Demonstration*
Underground Storage Tank Integrated Demonstration
Efficient Separations and Processing Integrated Program
Characterization, Monitoring, and Sensor Technology Integrated Program
Robotics Program
Innovative Investment Area
WGA - DOIT - Mixed Waste Working Group*
EM-30 Related, Planned, or Existing Facilities
Mixed Waste Management Facility (Lawrence Livermore National Laboratory)*
Mixed Waste Treatment Project (HQ Planning Activity)*
Oak Ridge Mixed Waste Treatment Facility*
Los Alamos Mixed Waste User Facility*
Idaho National Engineering Laboratory Facility*
Toxic Substance Control Act Incinerator - Oak Ridge*
Waste Examination and Repackaging Facilities (Idaho National Engineering Laboratory)*
Comprehensive Treatment and Management Plan Capital Projects (Rocky Flats)*
Controlled Air Incinerator (Los Alamos National Laboratory)*
Consolidated Incineration Facility (Savannah River Site)
NOTE: * indicates focused on low-level mixed waste and mixed transuranic waste.

3.1.6 Needed Technology Thrusts

The overall technology development strategy can be summarized as "treat-to-dispose" (i.e., treat mixed low-level waste to meet anticipated disposal requirements and prepare mixed transuranic waste to meet transportation and waste acceptance criteria, not RCRA treatment). The impact of this strategy will be to develop and demonstrate systems that have a broad applicability across the DOE complex. This strategy builds on current programs. It has two thrusts -- one on technical developments and one on establishing an infrastructure enhancing implementation of results.

Technical Developments Leading to System Demonstrations

This effort draws on the ability of the focus group to form the formal relationships with the customers and other appropriate parties to ensure institutional commitment to technology development directions and to implement successful technologies. Three key elements address each of the three major classes of waste considered. A systems approach will be used to integrate the work in each element, and based upon systems analysis, select a set of subsystems minimizing system cost and risk and maximizing performance.

Buried Waste (including associated contaminated soil) - Emphasis on Characterization, Retrieval, and Materials Handling: This waste requires greater attention to retrieval and materials handling than the two classes discussed below. The initial focus is on site characterization and retrieval. One major effort involves interfacing with the regulatory community while developing techniques that reduce the sampling and analysis time for up-front characterization. Improved non-invasive real-time sampling methods are being developed. Another major effort is remote surgical retrieval to minimize the amount of uncontaminated soil retrieved with buried waste and worker exposure to contaminated dust. Ex situ treatment and final waste forms will be coordinated with the heterogeneous and homogeneous efforts described below. Future plans include in situ processes for treating contaminated soils, which will be led by the Landfill Containment Focus Area.

Heterogeneous Waste (including debris) - Emphasis on Waste Destruction Treatments and Final Waste Forms: Destruction and/or conversion of a large fraction of the waste stream is required during production of a stable, final waste form. Initial emphasis has been placed on versatile thermal plasma systems using closed-loop offgas subsystems. Examples of recent starts are 1) mobile treatment systems for transport to various sites for waste destruction; 2) innovative technologies for offgas cleanup, alternatives to incineration, membranes, and catalytic mercury removal; 3) removal of debris from land disposal restriction (LDR) waste using thermal desorption or other approved debris rule treatments; 4) process diagnostics for on-line/at-line and real-time process controls and monitors; and 5) interfacing with regulators to link pre-processing characterization of waste streams to the treatment process (e.g., robot treatment systems may require less pre-processing characterization). Future plans include characterizing waste for transportation, developing and demonstrating materials handling systems for waste containers other than drums, and establishing waste acceptance criteria and a waste form decision framework in conjunction with customers and, in turn, with regulators and stakeholders. Characterization, retrieval, and materials handling will be coordinated with those activities under the buried waste effort.

Homogeneous Waste - Emphasis on Characterization, Waste Stabilization Treatment, and Final Waste Form: Initial emphasis has been placed on vitrification of sludges and polymer encapsulation of nitrate and chloride-bearing salts. In addition, the destruction of some RCRA organic constituents may be required. Characterization, retrieval, and materials handling will be coordinated with the buried waste effort. Closed-loop systems, innovative technologies, and interfacing with the regulators will be coordinated with the heterogeneous waste activities.

The Establishment of an Infrastructure

This thrust seeks to establish EM-wide agreement on the priorities for technology development and formal mechanisms to assist timely implementation of results. It draws on the capability of the focus area to set up formal relationships with the customer and, working with the customer, establish formal relationships with regulators and stakeholders. Key elements include the following:

Regulatory: This effort will set up formal mechanisms, in conjunction with EM customers and DOE senior executives while involving technology developers, regulators, stakeholders, to 1) work toward risk-based treatment standards for mixed waste, 2) link characterization requirements to treatment requirements and capabilities to obtain waste stream information needed for safe and effective processing, 3) establish waste acceptance criteria to test and evaluate final waste forms, 4) streamline permitting for mobile treatment systems to minimize the need for transportation of unprocessed waste and investment in fixed facilities at sites with small waste stream volumes, and 5) resolve the degree to which technology development and implementation are incorporated in site compliance agreements.

DOE-Institutional: This effort will work toward 1) establishing EM-wide agreement on waste streams that pose the greatest total risk and payback to DOE for treatment and using these attributes to establish technology development priorities, preferred policy options, and treatment goals for these streams; 2) establishing agreement on a set of validated technology development needs for these streams and priorities for technology development and customer use of the results; 3) resolving difficult issues such as the EM-30 concerns regarding near-term waste forms meeting land disposal restrictions for "restorage" rather than disposal; and 4) increasing industrial participation wherever possible, considering private sector concerns such as market size, regulatory acceptance, transition from bench-scale to commercial operations, and contractors' limits to liability.

Stakeholders: This effort will increase the use of organizations such as the WGA to involve regulators and stakeholders in planning and reviewing technology and system demonstrations. (See Section 3.3.1 for additional details.)

Schedule: This will address the windows of opportunity and set technology development milestones to meet FFCAct and treatment facility permitting schedules, RODs, and other compliance agreements.

National Perspective: This requires several mechanisms including disseminating information rapidly; establishing a mixed waste forum; and coordinating with sites, programs, and focus areas.

3.2 Management Approach

The approach described in Section 1.3 forms the basis for the Mixed Waste Focus Area. In addition to the general benefits of the new approach cited in Section 1.0, cost savings may also be achieved by consolidation of management functions and development projects between the Buried Waste Integrated Demonstration, the Mixed Waste Integrated Program, and others. Examples include consolidating systems analysis and integration by the Operations Office and combining parallel technology testing and evaluation efforts.

3.2.1 Organizational Structure and Roles

The Mixed Waste Focus Area will follow the organizational elements described in Section 1.3. The EM members of the Management Team should have scientific and technical backgrounds including, for example, experience managing technology development programs; systems engineering and implementation with an emphasis on hazardous and radioactive materials handling; physical, chemical, and thermal processing; the mixed waste regulatory and stakeholder arenas; and EM operations.

The Implementation Team must have demonstrated capabilities to develop, design, and analyze field-scale engineered systems for treatment or processing of hazardous and radioactive materials with experience applicable to mixed waste characterization, automated handling, waste destruction and stabilization, systems analysis and integration, regulatory requirements, and stakeholder interfaces. Participation in the Implementation Team will include National Laboratories, Operations Offices, universities, industry, or other organizations, depending upon their capabilities to lead areas of 1) characterization, retrieval, and materials handling; 2) waste destruction; 3) waste stabilization; 4) systems analysis and integration; and 5) to lead non-technical aspect such as interfaces with the regulatory and stakeholder communities.

3.3 Essential Partnerships and Linkages

Essential to the success of this focus area is the development of partnerships between interested and affected individuals and groups (See Table 3.5).

3.3.1 Stakeholder Involvement

Stakeholder interaction/participation in the decision-making process will be achieved through site-specific committees as part of the site public outreach plan as well as in regional and national activities. Existing EM activities such as the Stakeholders Initiative, WGA-DOIT Committee's, Mixed Waste Working Group, FFCAct, STGWG and the Site-Specific Advisory Boards will be used to facilitate mixed waste coordination with a diverse set of environmental activist groups, Indian tribes, citizens and business groups, and government and elected officials.

The focus area may use the WGA-DOIT Committee's Mixed Waste Working Group to continue bringing together stakeholders from around the nation to chart a course and develop consensus for accelerated testing of innovative mixed waste technologies and encouraging new private sector partnerships through formal solicitation of proposals for creative new technological regulatory or instructional approaches to mixed waste. The Mixed Waste Working Group has identified nine DOE projects for candidate 1994 demonstrations that offer potential for breakthrough innovation, regulatory and host community acceptance, broad deployment, and ultimate commercialization.

Table 3.5 Interactions with Mixed Waste Focus Area

Stakeholder Involvement	EM Integration	Other DOE Integration	External Interactions
Stakeholders will participate principally through existing activities at the site, regional, and national level such as: • Stakeholders Initiative • Site coordinating committees • WGA-DOIT Mixed Waste Working Group • FFCAct NGA • State and Tribal Government Working Group	• EM-30 waste-type strategic planning program managers for mixed low-level waste and mixed transuranic waste, and possibly, low-level and hazardous waste • Site representative for EM • Other focus area such as facility transi-tioning, tanks, and landfill stabilization • High-level waste vitri-fication for experience applicable to mixed waste vitrification	• ER for innovative breakthrough technologies and instrumentation • EE for waste treatment technologies • DP for Complex 21 and other technology areas • NE for applicable reactor program technologies • RW for applicable private sector applications	• Government agencies such as EPA, NIST, DoD, DOI, and DOT • Industry and academia, which develop and/or implement relevant technologies • Government agencies such as DoD which have waste treatment needs relevant to mixed waste • Nuclear Regulatory Commission • External and peer review groups

3.3.2 Integration across EM

The magnitude of the mixed waste problem and relative scarcity of resources available to accomplish the cleanup task necessitate that EM technology development organizations improve their communication and interactions (Table 3.5). To ensure that technology resources are used efficiently, technology development and user groups will

- Integrate needs identification and program development efforts to meet real-time site needs.

- Take joint responsibility for technology planning, development, demonstration, and implementation.

- Effectively communicate progress and problems with technology development to learn from each site's successes and mistakes.

- Address political and regulatory mandates, and formally link technology development efforts to regulatory milestones and decision points.

- Ensure that existing programs and those to be developed are complementary.

This increased cooperation needs to begin immediately to provide maximum input of technology development in the draft and final site treatment plans required by the FFCAct, due, respectively in August 1994 and October 1995. Other plans include the following:

- Working with facility transition and material deactivation (EM-60) to ensure that mixed waste streams generated during these activities are compatible with planned treatment capabilities, or that new needs are identified.

- Integrating all transuranic waste with the ongoing WIPP characterization program and other activities to ensure that technology development needs for transportation and Waste Acceptance Criteria for mixed transuranic waste are addressed adequately.

- Coordinating all EM elements on macro-level systems analysis to ensure that the Mixed Waste Focus Area coordinates and integrates with complex-wide configurations, baseline treatment flowsheet analysis, cost, risk, and other overall system activities.

- Coordinating with the high-level waste vitrification activities to ensure that application of vitrification to mixed waste benefits from the 20 years of experience in treatment and technology development for high-level wastes.

- Working with the proposed Focus Areas (i.e., Facility Transitioning, Decommissioning, and Final Disposition; High-Level Waste Tank Remediation; and Landfill Stabilization) to ensure that planned treatment capabilities are compatible with waste to be generated, to identify new needs, and to coordinate on in situ treatments for buried waste.

- Evaluating crosscutting basic research and development activities for applicability to mixed waste.

3.3.3 Integration across DOE

Other DOE programs conduct work relevant to mixed waste (Table 3.5). The Mixed Waste Focus Area will coordinate with these groups to integrate their development and basic research capabilities as part of the scientific and technical foundation for the program. Examples include the following:

- ER basic research programs and key emerging capabilities (e.g., high-temperature, optically based diagnostics such as laser spark spectroscopy to identify and quantify metal components).

- Office of Nuclear Energy, Integral Fast Reactor Program (e.g., pyroprocess development for recovery of transuranic elements from light-water reactors).

- EE industrial waste reduction program initiatives (for treatment of electroplating waste).

- DP basic and applied programs in waste minimization, radioactive and hazardous materials handling and processing, Non-Destructive Assay (NDA), automation, process monitoring and control, and associated Complex-21 activities..

3.3.4 External Interactions

Key external interactions (see Table 3.5) are anticipated to be with industry, as potential vendors of technologies and services; with other government agencies, such as NIST, which develop technologies relevant to mixed waste treatment; with agencies such as DoD and DOI, which have waste treatment needs analogous to those of mixed waste; and with regulators and stakeholders, who are instrumental in acceptance of waste treatment. The focus area will use other mechanisms, such as the proposed mixed waste forum, peer reviews, or other mechanisms to foster interactions, with goals such as the following:

- Improving regulatory and public knowledge and acceptance of technology development products.

- Facilitating technology development linkages in regulatory agreements such as the Site-Specific Treatment Plans.

- Improving definition and cohesiveness of regulatory requirements that apply to mixed waste disposal.

- Enhancing the participation of industry in EM-50 to facilitate technology transfer and commercialization through procurement vehicles such as Technology Task Plans Research Opportunity Announcements, and Program Research and Development Announcements.

- Improving the understanding of other technology foundations applicable to mixed waste through coordination with other Federal agencies, industry, academia, and international organizations.

- Using external technical resource cooperation to improve the timeliness and quality of technical solutions and leveraging of EM dollars through CRADAs, licenses, and other procurement vehicles.

- Ensuring that objective technical and management feedback is addressed in program development and execution.

- Developing linkages to the private sector.

3.4 Metrics for Success

The Mixed Waste Focus Area will employ metrics to track the success of the program in meeting its objectives. Both long- and short-term measurements will be utilized to ensure that accurate progress can be measured and continually directed to produce the desired end results.

The program will involve internal and external review to determine success levels based on these measures. Specific performance measures tailored to the Mixed Waste Focus Area will be developed consistent with those shown on Section 1.5 and the mixed waste stream treatment baselines to be developed through the final site treatment plans by EM-30 and similar baselines as applicable for EM-40 and EM-60.